

4
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OF
CIVIL ENGINEERS



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BOSTON SOCIETY OF CIVIL ENGINEERS

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Editor—EDWARD C. SHERMAN

6 Beacon Street, Boston

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PROCEEDINGS

PAPERS IN THIS NUMBER.

Discussion of "Boston Foundations."

Address at the Annual Meeting, March 18, 1914. Frederic H. Fay.

CURRENT DISCUSSIONS.

Paper.	Author.	Published.	Discussion Closes.
1. "Boston Foundations."	J. R. Worcester.	Jan.	May 10.
2. "Main Drainage Works Proposed for New York."	Geo. A. Soper.	Feb.	April 15.
3. "Fall River Bridge."	J. W. Rollins.	Feb.	April 15.
4. "Engineering Lessons from the Ohio Floods."	John W. Alford.	March.	May 15.
5. "Bitulithic Pavement and Warrenite Roadway."	G. H. Perkins.	March.	May 15.
6. "Cost Accounting on Con- struction Work."	Leslie H. Allen.	March.	May 15.

NOTE. At the request of a number of members of the Society the date of closing the discussion of "Boston Foundations" has been extended to May 10.

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REGULAR MEETING.

A REGULAR meeting of the Boston Society of Civil Engineers will be held on Wednesday, April 15, 1914, at 7.45 o'clock P.M., in

CHIPMAN HALL, TREMONT TEMPLE, BOSTON.

Business of the Meeting. — To consider the recommendation of the Board of Government, made in its report submitted at the annual meeting, regarding the use of a portion of the income from the Permanent Fund for current expenses.

Mr. F. H. Fay offers the following amendments to By-Law 9: Add after the word "fund" at the end of the first sentence the words, "provided, however, that the income of the fund, or any portion thereof, in any year may be used for current expenses of that year, at the discretion of the Board of Government"; and insert in the second sentence after the word "money" the words "other than income above specified." The By-Law will then read: PERMANENT FUND. — There shall be a fund called the Permanent Fund, to which shall be added all money received for entrance fees and all income from investments of the fund, *provided, however, that the income of the fund, or any portion thereof, in any year may be used for current expenses of that year, at the discretion of the Board of Government.* No money, *other than income above specified,* shall be appropriated from the fund except by a two-thirds vote at two successive regular meetings. Any such appropriation or any part thereof not used within three years shall be returned to the fund.

Mr. J. S. Miller, Jr., assistant chief chemist of the Barber Asphalt Paving Company, will give a lecture illustrated by lantern slides and motion pictures entitled, "Asphalt and Asphaltic Street and Road Construction."

S: E. TINKHAM, *Secretary.*

MINUTES OF MEETINGS.

BOSTON, February 25, 1914. — A special meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, and was called to order by the President, Mr. Frederic H. Fay, at 8.15 o'clock. There were 45 members and visitors present.

The meeting was devoted to a discussion of Mr. J. R. Worcester's paper on "Boston Foundations," printed in the January number of the JOURNAL.

Among those who took part in the discussion were the following: Charles R. Gow, Charles T. Main, Henry F. Bryant, L. B. Manley, A. O. Doane, E. W. Howe, J. E. Carty, J. R. Worcester and T. W. Clarke.

At 9.45 o'clock the meeting adjourned.

S. E. TINKHAM, *Secretary*.

BOSTON, MASS., March 18, 1914. — The sixty-sixth annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, 9 Beacon Street, Boston, at 12.30 o'clock P.M., President Frederic H. Fay in the chair.

The reading of the record of the regular meeting held on February 18 was by vote dispensed with, and it was approved as printed in the March JOURNAL. The Secretary read the record of the special meeting held February 25, and by vote it was approved.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named:

Member — August Fredrik Bildt.

Junior — Miles Erskine Langley.

The Secretary read the annual report of the Board of Government, and by vote it was accepted.

On motion of Prof. C. F. Allen, it was voted, That the recommendation of the Board of Government regarding the Permanent Fund be made a part of the business of the next regular meeting of the Society.

The Secretary read his annual report, and by vote it was accepted.

The Treasurer presented and read his annual report, omitting the tables. From these tables he gave brief abstracts. By vote the report was accepted.

The Librarian read the report of the Committee on the Library, and by vote the report was accepted and the recom-

mendation appropriating \$60 for the purchase of current engineering books was adopted.

Mr. Charles R. Gow, for the Committee on Excursions, presented a brief report which was accepted.

On motion of Mr. Bryant it was voted to refer to the Board of Government the question of appointing the special committees of the Society, with full power to act.

The Secretary read a letter from Past President John R. Freeman, in which he stated that he had shipped to the Society one of the Bausch & Lomb convertible balopticans, together with an aluminum screen and tubular stand for supporting the apparatus. He stated that this baloptican he believed to be the most complete apparatus in the market, as it would permit post cards, mineralogical specimens, or anything of that sort, including photographs up to eight inches square, to be shown by opaque projection.

On motion of Mr. C. W. Sherman, the thanks of the Society were voted to Mr. Freeman for his generous gift.

Past President E. W. Howe, at the request of the President, presented in the name of the Society the Desmond FitzGerald medal for the year 1913 to David Alfred Hartwell, for his paper entitled, "The Fitchburg, Mass., Intercepting Sewer." Mr. Hartwell in accepting the medal expressed his deep appreciation of the honor conferred upon him in the award of the medal.

Mr. R. E. Curtis spoke briefly of the joint engineering meetings which had been held in Boston for several years past, and suggested that greater coöperation of the various engineering organizations in Boston would add very much to the advancement of the profession. On motion of Mr. Bryant, it was voted that the Board of Government be requested to appoint a committee of three to consider means for further coöperation among the various societies.

The retiring President, Mr. Frederic H. Fay, then delivered an address, which will be found on page 249 of this number of the JOURNAL.

The tellers of election appointed by the President, Messrs. Edward W. Howe and Harry F. Sawtelle, submitted their report giving the result of the letter ballot, and in accordance with this

report the President announced that the following officers had been elected:

President — Harrison P. Eddy.

Vice-President (for two years) — Richard A. Hale.

Secretary — S. Everett Tinkham.

Treasurer — Charles W. Sherman.

Directors (for two years) — Charles M. Allen and Leonard C. Wason.

The President then introduced the President-elect, Mr. Harrison P. Eddy, who thanked the members of the Society for the honor they had bestowed on him in this election, and promised his best efforts, with the aid of the other officers selected, to advance the interests of the Society.

The members then adjourned to the auditorium of the City Club, where members and guests to the number of 118 sat down to the thirty-second annual dinner.

After the dinner Mr. Nelson P. Lewis, chief engineer, Board of Estimate and Apportionment of the City of New York, gave an exceedingly interesting address, illustrated with lantern slides, on "City Planning from the Standpoint of the Engineer."

In the evening the usual "Smoker" was held in the auditorium, the attendance being about 250. The gathering was of the same character as in former years, and in addition to music by an orchestra and songs by members, entertainment was furnished by Mr. Chevalier, magician, Mr. Bradley, singer, and Mr. Martin in Italian dialect.

S. E. TINKHAM, *Secretary*.

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, MASS., March 4, 1914. — The annual meeting of the Sanitary Section, Boston Society of Civil Engineers, was held this evening at the Engineers Club.

A special dinner was served in the main dining room of the Club at 6.15 o'clock, to 49 members and guests. As this was the tenth annual meeting of the Section, special features were introduced during the dinner, such as stories and short speeches

by various members, which helped to make the dinner a very enjoyable one.

Mr. E. S. Dorr gave a few words of welcome to the guest of the evening, Mr. George S. Webster, of Philadelphia, to which Mr. Webster responded. Several of the past chairmen were called upon, — Messrs. George C. Whipple, George A. Carpenter and Harrison P. Eddy, — as well as other members. A choice collection of stories and songs were given by Mr. W. B. C. Fox, assisted by the chairman at the piano, which added greatly to the fun.

The annual business meeting of the Sanitary Section was opened in the Assembly Hall at 7.30 o'clock, by Chairman Edmund M. Blake.

The minutes of the December and January meetings were approved as printed in the *Bulletin* and JOURNAL of the Society respectively.

The minutes of the February meeting were read by the Clerk and approved as read.

The Committee on Rainfall and Run-off presented their final report, covering several years' work and embodying the data relating to the measurement of rainfall, run-off, the results of gagings, a bibliography, and other information collected by the committee.

On motion of C. W. Sherman, seconded by F. B. Sanborn, it was voted that the report be accepted and the committee discharged.

H. P. Eddy moved that the report be referred to the Executive Committee of the Section for such action as they should decide upon. The motion was seconded by W. S. Johnson and carried.

It was suggested that the report be printed in the JOURNAL and that thereafter a meeting be arranged for discussion of the subject. In order to give the members a brief knowledge of the points covered by the report, Mr. George A. Carpenter, chairman of the committee, gave a short résumé.

The report of the Committee on Sewerage Statistics was read by Almon L. Fales, chairman. A brief discussion was presented by G. A. Carpenter.

On motion of G. C. Whipple, seconded by G. A. Carpenter, it was voted to accept the report and refer it to the Executive Committee with the suggestion that it be printed in the JOURNAL and discussed at some future meeting; also, that a copy of the report when printed be sent to the United States Census Bureau by the Clerk.

The report of the Executive Committee for the past year was then read by the Clerk.

It was moved by W. S. Johnson, seconded by F. P. Stearns, that the report be accepted and placed on file, and it was so voted.

H. P. Eddy made a motion, seconded by E. S. Dorr, that the report be referred to the incoming Executive Committee to consider the suggestions offered, and the motion was carried.

The report of the informal nominating committee was presented by E. S. Dorr, chairman, with nominations for officers and members of the Executive Committee for the ensuing year, as follows:

Chairman, Bertram Brewer.

Vice-Chairman, Elliott R. B. Allardice.

Clerk, Frank A. Marston.

Executive Committee (additional members): David A. Hartwell, Dwight Porter, Edmund M. Blake.

No further nominations were offered, and on motion of C. W. Sherman, duly seconded, it was voted to close nominations.

C. W. Sherman then moved that Mr. Dorr be instructed to cast one ballot for the officers and members of the Executive Committee as nominated. It was seconded and duly carried. Mr. Dorr cast a ballot as instructed, and the officers and members of the Executive Committee as above stated were declared elected.

As there was no further business to come before the meeting at that time, a short intermission was declared before taking up the literary program.

Shortly after 8 o'clock, the Chairman introduced, as the speaker of the evening, Mr. George S. Webster, chief engineer and surveyor of the Bureau of Surveys of Philadelphia, who presented a very interesting and instructive paper on "The

Collection and Treatment of Sewage in Their Relation to the City of Philadelphia." Mr. Webster described the proposed plans for intercepting and treating the sewage of the city before its final disposal by discharge into the rivers. He also showed the similarity between the proposed plans and those now in operation under similar conditions in such foreign cities as Dresden, Berlin, Frankfort, London, Birmingham and others. The recently completed sewage treatment plant at Pennypack Creek, Philadelphia, was described in some detail. The paper was well illustrated by lantern slides, and aroused considerable interest.

Mr. Frederick P. Stearns discussed the paper and referred to the oxidizing action of river water and the self-purification of streams as illustrated at Pittsburg, Pa., and the Chicago Drainage Canal.

Mr. Frederick H. Fay, president of the Boston Society of Civil Engineers, spoke on behalf of the Society in offering congratulations to the Section on the high standing which had been maintained during the past ten years and on the character of the papers, which he considered were worthy of a national society.

It was voted to extend the thanks of the Section to Mr. Webster for his courtesy in presenting the paper.

Chairman Edmund M. Blake spoke briefly in appreciation of the assistance accorded him by the members during the past year. Mr. Webster also spoke of his interest in the work the Section was doing.

On motion of G. A. Carpenter, it was voted to extend the retiring chairman, Mr. Edmund M. Blake, a vote of appreciation for his earnest efforts in behalf of the Section which had contributed largely toward the success of the past season.

The newly-elected chairman, Mr. Bertram Brewer, was then introduced.

There were 80 present at the meeting. Adjourned at 9.50 o'clock.

FRANK A. MARSTON, *Clerk.*

ANNUAL REPORTS

ANNUAL REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1913-14.

BOSTON, MASS., March 18, 1914.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the Constitution, the Board of Government submits its report for the year ending March 18, 1914.

At the last annual meeting the total membership of the Society was 823, of whom 754 were members, 28 juniors, 2 honorary members, 23 associates and 16 were members of the Sanitary Section only.

During the year the Society has lost a total of 24 members, 16 by resignation, 5 by forfeiture of membership for non-payment of dues, and 3 have died.

There has been added to the Society during the year a total of 38 members of all grades; 37 have been elected and one has been reinstated; 4 juniors and one member of the Sanitary Section have been transferred to the grade of member.

The present membership of the Society consists of 2 honorary members, 762 members, 37 juniors, 22 associates and 14 members of the Sanitary Section only, make a total membership of 837.

The record of deaths during the year is —

George Blinn Francis, past president, died June 9, 1913.

George A. Nelson, died June 3, 1913.

Edward A. Haskell, died August 24, 1913.

As required under By-Law 8, the Board reports that for good and sufficient reasons it has remitted this year the dues of eleven members of the Society. Since this action of the Board the dues from three of these members have been received, and of the remainder more than half are so far away that there has not been sufficient time to receive a reply to the last notice sent them.

Ten regular and three special meetings have been held during the year. The average attendance at the meetings was 123, as against 175 last year, the largest being 300 and the smallest 36.

The following papers and talks have been given at the meetings:

March 19, 1913. — J. Waldo Smith, "Some Features of the Contracts, Specifications and Construction of the Catskill Water Supply for the City of New York." (Illustrated.)

April 16, 1913. — James H. Sullivan, "Paving Progress in Greater Boston," with discussion.

May 13, 1913 (special students' meeting). — James W. Rollins, "Reminiscences of an Engineer."

May 21, 1913. — Charles M. Spofford, "The Technology Summer Surveying Camp at East Machias, Maine." (Illustrated.)

June 25, 1913. — Charles B. Breed, "Elimination of Grade Crossings at Lynn, Mass." (Illustrated.)

September 17, 1913. — Leonard C. Wason, "The Problems of a Contractor." (Illustrated.)

October 15, 1913. — John L. Howard, "The Work of the Directors of the Port of Boston." (Illustrated.)

November 19, 1913. — John W. Alvord, of Chicago, "Engineering Lessons from the Ohio Floods." (Illustrated.)

December 17, 1913. — James W. Rollins, "Construction and Repairs of the Brightman Street Bridge, Fall River." (Illustrated.) G. H. Perkins, superintendent of refinery of Warren Brothers Company, "Bitulithic Pavement and Warrenite Roadway." (Illustrated.)

January 28, 1914. — Joseph R. Worcester, "Boston Foundations," with discussion. (Illustrated.)

February 11, 1914 (special meeting). — G. F. Ahlbrandt, metallurgical engineer, "Pure Iron versus Steel." (Illustrated.)

February 18, 1914. Luis G. Morphy, "Railroad Improvements at Worcester, Mass." (Illustrated.)

February 25, 1914 (special meeting). — Discussion on "Boston Foundations."

The Sanitary Section of the Society has held four meetings during the year, with an average attendance of 82. The following papers have been presented at the meetings of the Section:

March 5, 1913. — Dr. Shaoching H. Chuan, "A Glimpse of Tibet."

December 3, 1913. — Dr. George A. Soper, "The Main Drainage Works Proposed for New York City."

January 7, 1914. — Charles H. Paul, "The Arrowrock Dam of the United States Reclamation Service." (Illustrated.)

February 4, 1914. — George A. Carpenter, "Sewage Measurement and Automatic Storm Overflow Control at Pawtucket, R. I." C. G. Richardson, "The Venturi Meter for Measuring Sewage." (Illustrated.)

On May 13, 1913, for the third time, the students in the engineering courses at Harvard, Tufts and the Institute of Technology were the guests of the Society at a special meeting held at the Boston City Club. Past President James W. Rollins gave an illustrated talk on "Reminiscences of an Engineer." The attendance was about 300.

The plan of holding joint meetings with members of the American Society of Mechanical Engineers and the Boston Section of the American Institute of Electrical Engineers has continued during the past year, each organization arranging the program for one meeting.

The Board of Government has adopted the recommendation of the committee appointed to award the Desmond FitzGerald medal, and announces that it will be given this year for the paper entitled, "The Fitchburg, Mass., Intercepting Sewer," by David A. Hartwell, read before the Sanitary Section February 5, 1913.

The work of rearranging and cataloguing the library had progressed so far by the first of July last that the Assistant Librarian was able to attend to the clerical work of the Secretary in addition to the library work, and the services of a stenographer and custodian were dispensed with.

A slight change was made in the officers of the Society at the beginning of the year, by which the Secretary was made Librarian, all the executive work of the Society being thus placed in his charge, and a small saving in the amount paid for salaries being made.

During the year the Board has made some additions to the furnishings

of the Society rooms, the cost being paid from the special appropriation of \$2 000, made from the Permanent Fund in November, 1912; but the total amount paid from the appropriation to date has not exceeded the \$1 200 originally estimated for the furnishing of the rooms.

As a result of the letter-ballot canvassed at the regular meeting of June 25, 1913, the Society withdrew from membership in the Association of Engineering Societies on December 31, 1913, and with the issue for January, 1914, the Society began the publication of its own transactions under the title of the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS. Mr. Edward C. Sherman, a member of the Society, has been elected Editor of the JOURNAL, and the Society is to be congratulated on the excellent manner in which he has issued the first numbers of the JOURNAL. The high standard which has been set in the initial number, and the valuable material now on hand and in preparation for publication in succeeding numbers, give assurance that the first volume of the JOURNAL will be a credit to the Society.

The Board is of the opinion that the time has arrived when a readjustment of the financial policy of the Society is desirable. The most rigid economy is now necessary at all times to avoid the probability of a deficit at the close of the fiscal year, with the result that the Board is often seriously restricted in the adoption of policies which it considers would be advantageous to the Society's welfare.

That this condition should exist at a time when the Society is essentially financially prosperous is explained by the presence in our By-Laws of provisions whereby certain portions of the yearly income are required to be added to the Permanent Fund, from which, at present, the Society derives no benefit. The yearly accretion from interest now added to this fund as shown by the report of the Treasurer is in excess of fifteen hundred dollars, and is rapidly growing.

In general it may be said that a loss results in current funds on account of each member's first year in the Society. This is a result of that provision of the By-Laws which requires that all entrance fees shall pass to the Permanent Fund and that the dues for the initial year shall be reduced by fifty per cent. In other words, a great influx of new members in a given year is a handicap to the financial operations of the Society's affairs rather than a benefit, as it obviously should be.

The Board believes that this anomalous condition should be corrected by a provision which would permit the Board of Government, in its discretion, to apply to legitimate current expenses in any year, such portion of the income from the Permanent Fund for that year as it may deem necessary. Such a provision would of course necessitate an amendment to the present By-Laws, and the Board recommends that such an amendment be made.

For the Board of Government,

FREDERIC H. FAY, *President*.

BOSTON SOCIETY OF CIVIL ENGINEERS.

REPORT OF THE TREASURER.

BOSTON, March 18, 1914.

To the Boston Society of Civil Engineers:

Your Treasurer submits his report for the year ending March 18, 1914.

The data are contained in the appended tabular statements: Table 1, profit and loss statements for four years; Table 2, comparative balance sheets; Table 3, investment of the Permanent Fund; Table 4, statement of cash balance; and Table 5, growth of the Permanent Fund.

The income applicable to current expenses has been \$7 898.34 — about \$400 more than for the previous year. The expenses have been \$8 672.78, or about \$1 800 greater than for last year, showing a net loss for the year of \$774.44. The fact that there is a loss is due wholly to the extraordinary character of the January issue of the JOURNAL, resulting in a very large cost for illustrations. Under ordinary conditions in this respect, the year's accounts would have shown a very close balance.

The expense of issuing two numbers of the JOURNAL, \$1,473.53, affords no basis for estimating the ordinary cost of our magazine, since the excess cost of the January issue and the expenses of making a start are included. If these extraordinary expenses were eliminated, the account would probably be reduced by about \$800.

It is worthy of note that although the income for advertising has been less than \$1 000, the annual value of the advertising contracts now in force is nearly \$1 600, indicating the appreciation of our new JOURNAL as an advertising medium, as well as the work which has been done in soliciting advertising.

The best estimate which it is possible to make at this time indicates receipts for next year of \$8 400, and expenses of \$8 000, which would leave a balance of \$400 for unforeseen expenses.

There has been added to the Permanent Fund during the year, \$1 930.45, or about \$30 more than for the preceding year. There has been an increase of over \$200 from interest, and a decrease of about \$200 in the amount of entrance fees. These fees have been less in amount than for five or six years past.

There has been expended during the year from the appropriation for improving and furnishing the rooms, \$199.94, leaving \$851.46 unexpended.

The present value of the Permanent Fund, excluding this appropriation, is \$31 864.29. This statement is based upon the "book values" of securities as carried upon the Society's books, and represents the cost of the bonds and stocks with but one or two exceptions. The values are somewhat higher than present market values, and if the latter were used, the value of the Permanent Fund would be about \$700 less. The book values are believed to represent more nearly the normal values of the securities than the present market values. No account has been taken in these statements of the accrued interest upon bonds, the value of which increases slightly from year to year, but not enough to affect the comparisons or general statements made above.

Respectfully submitted,

CHARLES W. SHERMAN, *Treasurer.*

TABLE I.—PROFIT AND LOSS STATEMENTS.

Income:	1910-11.	1911-12.	1912-13.	1913-14.
Members' Dues.....	\$4 567.00	\$6 448.50	\$6 443.00	\$6 671.59
Advertisements.....	1 004.50	984.50	938.50	973.00
Sales of JOURNAL.....	4.50	8.25	9.40	33.55
Library Fines.....	4.75	5.56	7.28	8.01
Interest.....	10.47	22.81	95.30	159.25
Excursion Committee.....				52.94
Total Current Income....	\$5 591.22	\$7 469.62	\$7 493.48	\$7 898.34
Entrance Fees.....	\$945.00	\$410.00	\$525.00	\$315.00
Contributions.....	200.00	100.00	100.00	100.00
Interest.....	1 231.78	1 301.72	1 277.70	1 515.45
Total Income Permanent Fund.....	\$2 376.78	\$1 811.72	\$1 902.70	\$1 930.45
Appropriation from Permanent Fund.....			\$2 000.00	
Balance from Previous Appropriations.....				\$1 051.40
Total Available from Appropriations.....			\$2 000.00	\$1 051.40
Surplus Account.....	\$1.50			
Deficit for the year (Current Funds).....	940.26			\$774.44
	<u>\$8 909.76</u>	<u>\$9 281.34</u>	<u>\$11 396.18</u>	<u>\$11 654.63</u>
Expense:				
Association Eng. Societies..	\$1 912.62	\$2 010.00	\$2 026.25	\$1 564.38
Bulletin.....	*	763.83	783.49	687.75
JOURNAL B. S. C. E. (incl. Editor's salary).....				1 473.53
Printing, Postage, Stationery,	1 770.96	593.16	644.46	838.54
Rent (net).....	856.74	920.00	1 320.75	1 632.00
Light.....	53.76	49.68	70.31	62.38
Salaries (except Editor)....	1 007.00	992.00	1 248.50	1 358.00
Reporting.....	282.00	68.00	20.50	41.00
Stereopticon.....	180.00	130.00	134.50	107.50
Books.....	72.10	40.53	52.11	33.10
Binding.....	81.20	169.30	81.15	197.25
Periodicals.....	31.00	47.00	34.25	58.15
Incidentals and Repairs....	79.45	84.94	87.77	62.40
Insurance.....	26.38	26.38	26.38	41.87
Telephone.....	59.82	65.24	66.27	50.82
Sanitary Section Incidentals,	45.00	14.24	22.55	64.90
Annual Meeting and Dinner,	43.45	220.82	73.09	73.38
Furniture.....	31.50	34.25	2.50	
Navigation Congress.....			20.00	20.00
Students' Meeting.....			154.50	206.48
Catering.....				45.00
Excursions.....				38.00
Lantern Slides.....				16.35
Total Current Expense...	<u>\$6 532.98</u>	<u>\$6 229.37</u>	<u>\$6 869.33</u>	<u>\$8 672.78</u>

* Included in Printing, Postage, etc.

BOSTON SOCIETY OF CIVIL ENGINEERS.

	1910-11.	1911-12.	1912-13.	1913-14.
<i>Brought forward</i>	\$6 532.98	\$6 229.37	\$6 869.33	\$8 672.78
Furniture.....			\$573.15	\$149.50
Alterations in Rooms.....			375.45	50.44
Total expended from Appropriations.....			\$948.60	\$199.94
Permanent Fund increase...	\$2 376.78	\$1 811.72	\$1 902.70	\$1 930.45
Unexpended Balance of Appropriation.....			1 051.40	\$851.46
Increase for the year, Current Funds.....		1 240.25	624.15	
	<u>\$8 909.76</u>	<u>\$9 281.34</u>	<u>\$11 396.18</u>	<u>\$11 654.63</u>

NOTES ON TABLE 1.

Dues.	Received from Secretary.....	\$6 651.59
	Deduct 1914-15 dues in advance.....	58.00
		<u>\$6 593.59</u>
	Add dues paid in advance last year.....	78.00
	Total Current Dues.....	<u>\$6 671.59</u>
Rent.	Received from Secretary, rent paid by subtenants, as follows:	
	Hersey Mfg. Co.....	\$500.00
	N. E. W. W. Assn.....	400.00
	N. E. Assn. Gas. Engrs.....	100.00
		<u>\$1 000.00</u>

The gross rent for the Society's rooms amounts to \$2 475 per year. In addition \$15 is paid for the use of the hall at each meeting. The rent paid for a hall for the Sanitary Section has been entered under the heading of "Sanitary Section" and not as rent.

TABLE 2. — COMPARATIVE BALANCE SHEETS.

Assets:	March 20, 1912.	March 19, 1913.	March 18, 1914.
Cash.....	\$1 033.27	\$353.26	\$119.41
Bonds.....	22 975.50	26 615.50	27 605.50
Stocks.....			1 950.00
Coöperative Banks.....	6 667.83	5 315.80	3 545.72
Savings Banks.....	132.21		
Accounts Receivable (rent).....	145.83	145.83	145.83
Library.....	7 500.00	7 500.00	7 500.00
Furniture.....	600.00	1 175.65	1 325.15
	<u>\$39 054.64</u>	<u>\$41 106.04</u>	<u>\$42 911.61</u>

PROCEEDINGS.

15*

Liabilities:	March 20, 1912.	March 19, 1913.	March 18, 1914.
Permanent Fund.....	\$30 031.14	\$29 933.84	\$31 864.29
Unexpended Appropriations.....		1 051.40	851.46
Current Funds	686.00	1 310.15	535.71
Accounts Payable.....	237.50	135.00	115.00
Surplus.....	8 100.00	8 675.65	8 825.15
	<u>\$39 054.64</u>	<u>\$41 106.04</u>	<u>\$42 191.61</u>

TABLE 3. — INVESTMENT OF PERMANENT FUND, MARCH 18, 1914.

	Par Value.	Cost.	Present Market Value.	Value as Carried on Books.
Bonds.				
Am. Tel. & Tel. Co. col. tr. 4%, 1929.....	\$3 000.00	\$2 328.75	\$2 662.50	\$2 737.50
Republican Valley R. R. 6%, 1919.....	600.00	616.50	612.00	618.00
Union El. Lt. & Pr. Co. 5%, 1932.....	2 000.00	2 050.00	2 020.00	2 050.00
Blackstone Valley Gas & Elec. Co., 5%, 1939.....	2 000.00	1 995.00	1 980.00	1 995.00
Dayton Gas Co. 5%, 1930.....	2 000.00	2 000.00	1 940.00	2 000.00
Milford & Uxbridge St. Ry. 5%, 1918.....	3 000.00	2 942.50	2 940.00	2 942.50
Railway & Light Securities Co. 5%, 1939.....	3 000.00	3 000.00	2 910.00	3 000.00
Superior Water, Lt. & Pr. Co. 4%, 1931.....	3 000.00	2 505.00	2 460.00	2 505.00
Wheeling Electric Co. 5%, 1941, Economy Light & Power Co. 5%, 1956.....	1 000.00	990.00	960.00	990.00
Tampa Electric Co. 5%, 1933..	2 000.00	2 000.00	1 960.00	2 000.00
Galveston-Houston Elec. Ry. 5%, 1954.....	2 000.00	1 940.00	1 900.00	1 940.00
Northern Texas Elec. Co. 5%, 1940.....	2 000.00	1 932.50	1 880.00	1 932.50
	<u>\$28 600.00</u>	<u>\$27 195.25</u>	<u>\$27 044.50</u>	<u>\$27 605.50</u>
Stocks.				
Am. Tel. & Tel. Co.....	1 500.00	1 950.00	1 807.50	1 950.00
	<u>\$30 100.00</u>	<u>\$29 145.25</u>	<u>\$28 852.00</u>	<u>\$29 555.50</u>
Co-operative Banks:				
25 shares Merchants Coöperative Bank.....				2 392.27
25 shares Volunteer Coöperative Bank.....				709.85
25 shares Watertown Coöperative Bank.....				443.60
				<u>\$33 101.22</u>
Cash:				
(Overdraft — borrowed from Current Funds and Appropriation) —				1 236.93
Total Value of Permanent Fund.....				<u>\$31 864.29</u>

TABLE 4. — STATEMENT OF CASH BALANCE, MARCH 18, 1914.

Value of Current Funds.....	\$535.71
Add Accounts Payable.....	115.00
	<u>\$650.71</u>
Deduct accounts receivable.....	145.83
Cash on hand, Current Funds.....	<u>\$504.88</u>
Unexpended Balance of Appropriation for Improving and Furnishing Rooms.....	851.46
	<u>\$1 356.34</u>
Permanent Fund, cash overdraft.....	<u>1 236.93</u>
Total cash on hand.....	<u>\$119.41</u>

TABLE 5. — GROWTH OF THE PERMANENT FUND.

Year.	Value of Permanent Fund.	Remarks.
1882	\$1 200.00	
1883	1 385.00	
1884	1 497.00	
1885	1 732.53	
1886	2 159.19	
1887	2 496.56	Spent for bookcases from Permanent Fund, \$80.63.
1888	2 572.56	\$200 appropriated from Permanent Fund to current funds.
1889	2 921.06	
1890	2 988.12	
1891	3 482.87	
1892	3 928.78	
1893	4 584.80	\$200 appropriated from current funds to Permanent Fund.
1894	5 098.40	
1895	5 865.56	
1896	6 640.21	
1897	7 599.38	
1898	8 423.01	
1899	9 252.91	
1900	10 010.38	
1901	12 787.55	\$2 017.50 appropriated from current funds to Permanent Fund.
1902	13 650.74	
1903	14 998.74	\$500 ditto.
1904	16 080.54	
1905	17 613.75	
1906	18 813.30	
1907	20 058.27	
1908	22 455.02	
1909	24 441.25	
1910	25 979.64	
1911	28 219.42	
1912	30 031.14	
1913	30 985.24*	\$2 000.00 appropriated from Permanent Fund for altering and furnishing rooms, but only \$948.60 spent up to date of report.
1914	32 715.75*	\$199.94 expended from appropriation.

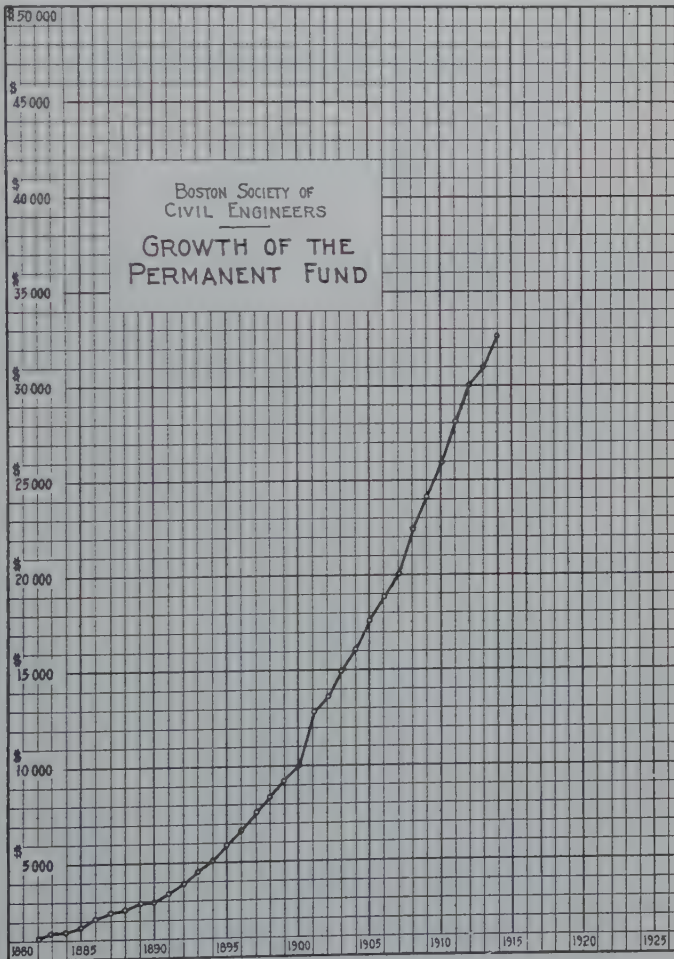
* Includes unexpended balance of appropriation.

NOTES ON TABLE 5.

The Permanent Fund was established by a vote passed at the annual meeting, March 15, 1882, as follows:

"Voted, that the income of the invested funds and the money received from entrance fees be added to a permanent fund and not used for current expenses."

At the time this vote was passed the Society had funds to the amount of \$1 200 par value invested in two \$600 railroad bonds. It should be noted that



the vote does not specifically devote these bonds to a permanent fund, but merely the income of the invested funds, and the money received from the entrance fees. Nevertheless it has been interpreted to mean that the \$1 200 was appropriated as the nucleus of the Permanent Fund, to which the income of the fund, and the entrance fees, were to be added.

In examining the figures in Table 5, it should be borne in mind that previous to 1911, the value of the Permanent Fund has been made up to include all investments at par. As nearly all of the investments were bought at less than par, and when they have been resold have also been usually sold at less than par, this has some times resulted in anomalous apparent gains or losses in the value of the Permanent Fund.

The growth of the fund is also shown graphically by the accompanying diagram.

REPORT OF THE AUDITING COMMITTEE.

BOSTON, MASS., March 17, 1914.

We hereby certify that we have this day examined the books and records of the Treasurer of the Boston Society of Civil Engineers for the year 1913-14; that all receipts are properly accounted for and that there are proper vouchers for all expenditures.

We have also examined the securities and investments of the Society's funds, have verified and compared same with the books and found them all accounted for and properly carried.

We have compared the financial statement of the Treasurer with the books and find it to be correct.

ROBERT SPURR WESTON,
JOHN N. FERGUSON,
Directors.

ANNUAL REPORT OF THE SECRETARY, 1913-14.

BOSTON, MASS., March 18, 1914.

S. EVERETT TINKHAM, Secretary, *in account with the* BOSTON SOCIETY OF CIVIL ENGINEERS. *Dr.*

For cash received during the year ending March 18, 1914, as follows:

From entrance fees, new members and transfers:

21 members.....	at \$10 =	\$210.00
16 juniors.....	at 5 =	80.00
4 juniors transferred to members.....	at 5 =	20.00
1 Sanitary Section member transferred to member.....		5.00
Total from entrance fees.....		\$315.00

PROCEEDINGS.

19*

From annual dues for 1913-14, including dues from new members.....	\$6 566.59
From back dues.....	27.00
From dues for 1914-15.....	58.00
Total from dues.....	\$6 651.59
From rents.....	1 000.00
From advertisements.....	973.00
From sale of JOURNALS.....	33.55
From contribution to building fund.....	100.00
Total.....	\$9 073.14

We have examined the above report and found it correct.

ROBERT SPURR WESTON,
JOHN N. FERGUSON,
Directors.

REPORT OF THE EXCURSION COMMITTEE.

BOSTON, March 18, 1914.

The Excursion Committee had deemed it inadvisable during the past year to conduct any excursions except that in connection with the June meeting, when arrangements were made for a visit of inspection to the grade-crossing elimination work at Lynn, Mass. There were 18 members in attendance on this occasion.

For the Committee,
CHAS. R. GOW, *Chairman.*

ANNUAL REPORT OF LIBRARY COMMITTEE, 1913-1914.

BOSTON, MASS., March 18, 1914.

To the Boston Society of Civil Engineers:

The Library Committee submits herewith its annual report for the year ending March 18, 1914.

During the year 236 volumes bound in cloth and 679 bound in paper have been added to the library, not including some 35 volumes bound in paper which have been received and are now in the hands of the binder.

These additions have brought the number of cloth-bound volumes in the library up to 7 500, and have kept the number of volumes bound in paper still in the vicinity of 2 000, in spite of the large amount of binding that has been done.

Fines to the amount of \$8.01 have been collected, and the committee is pleased to note that 309 books have been loaned to members, as against 204 loaned during the previous year, an increase of about 50 per cent.

Early in the year a few of the current engineering books were purchased, and a complete set of the Proceedings of the National Association of Cement Users, now the American Concrete Institute, has been bought recently. Most of the bound volumes added to the library, however, have consisted of

magazines, reports, and proceedings and transactions of Societies, which have been received in pamphlet form and bound at the Society's expense. Binding has seemed to be the only satisfactory way of preserving material that comes to us in this perishable form. A large mass of valuable material bound in paper was fast falling to decay, and it has seemed wise to your committee to preserve property of value already in the Society's possession, even if less actually new material were acquired. Among the volumes bound during the year may be mentioned ten volumes of the Proceedings of the Brooklyn Engineers' Club, seven volumes of the reports of the Isthmian Canal Commission, and a large number of volumes of the Minutes of the Proceedings of the Institution of Civil Engineers.

Much work has been done in the line of filling up gaps that existed in files of periodicals and society publications, and the committee has been greatly encouraged by the readiness of the members of the Society to contribute toward this work. Much indexing has also been done, though much remains to be done along both these lines.

Mr. Clemens Herschel has contributed a considerable number of volumes both to the general library and to the Herschel special library, and two new sections have been added to the cases containing the latter.

At the suggestion of several members, a section of advertising publications has been started, or rather, a former section of this nature which had not been kept up for some years has been revived. The firms applied to for material for this section have been very generous, and the committee feels that an excellent foundation has been laid for a collection of publications of this sort.

The exchange list of the JOURNAL is responsible for quite an increase in the number of periodicals received. In the matter of exchanges the JOURNAL has not confined itself to technical publications. The *Literary Digest*, *Harper's Weekly*, the *Outlook*, the *Atlantic Monthly* and *Harper's Magazine* are now on file at the rooms, and are apparently greatly enjoyed by the members. To the technical periodicals received regularly last year the exchange list has added the *American City*, *Canadian Engineer*, *Cement Era*, *Concrete-Cement Age*, *Journal of the Franklin Institute*, *Industrial Engineering*, *Machinery*, and the *Transactions* of the American Society for Testing Materials, the Connecticut Society of Engineers and the Engineers' Club of Philadelphia. The list of periodicals to which it is still necessary to subscribe is comparatively small.

To accommodate the above-mentioned increase in the number of magazines received, a new cabinet of some kind is needed, and the committee recommends that one be purchased.

The committee also recommends that the sum of sixty dollars be appropriated for the purchase of current engineering books during the coming year.

S. E. TINKHAM,

C. M. SPOFFORD,

FREDERIC I. WINSLOW,

Committee on Library.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 4, 1914.

The Sanitary Section can now look back on ten years of active work, the first annual meeting having been held March 2, 1904, at the United States Hotel, Boston.

During the past year two excursions have been held. One in June, an excursion around Boston Harbor to the three principal sewage outlet works, and the other in October, to the Calf Pasture Pumping Station of the Boston Main Drainage Works.

Meetings have been held in March, December, January and February at the Engineers' Club, at which the following papers were presented:

March 5, 1913. — "A Glimpse of Tibet," Shaoching H. Chuan, M.D.

December 3, 1913. — "The Main Drainage Works Proposed for New York," Dr. George A. Soper.

January 7, 1914. — "The Arrowrock Dam of the United States Reclamation Service," Charles H. Paul.

February 4, 1914. — Discussion. Subject, "The Measurement of Sewage Flow."

"Sewage Measurement and Automatic Storm Overflow Control at Pawtucket, R. I.," George A. Carpenter.

"The Venturi Meter for Measuring Sewage," C. G. Richardson, of the Builders Iron Foundry.

Written discussions by Messrs. Edward Wright, Jr., Frank A. Marston, Frank B. Sanborn, Edwin H. Rogers and E. J. Fort, chief engineer of the Bureau of Sewers, Brooklyn, N. Y.

The paper presented at the December meeting has already been published in the JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS, February, 1914.

The papers presented at the February meeting will be published shortly, and it is hoped to publish the January paper, the final report of the Committee on Run-Off, and the report of the Committee on Sewerage Statistics, as well as the paper to be presented at this annual meeting, so that the Section will be well represented in the first volume of the Society JOURNAL.

The attendance has been as follows:

	Attendance at	
	Dinner.	Meeting.
March annual meeting.....	48	68
June excursion.....	72	77
October excursion.....	..	25
December meeting.....	34	75
January special meeting.....	30*	125
February special meeting.....	35	60
Average attendance not including excursions.....	..	82

This average is an increase of 32 over that of last year and is the highest average attendance at our meetings for any season since the organization of the Sanitary Section.

* Dinner arranged impromptu.

There have been 9 members added since the last annual meeting, making the present total membership of the Section, 159, of which 14 are members of the Sanitary Section only and 2 are Juniors, all of the remainder being members of the Society.

As we look back over the ten years' record of the Sanitary Section, it is evident that a considerable amount of valuable information has been placed on record through the papers presented. The attendance at the meetings has been sufficient to demonstrate the high degree of interest aroused. We should not stop at this point, however, with a self-satisfied feeling, but should look further toward the possibilities to be reached. What has the Section accomplished in the way of research work? At the first annual meeting of the Section the Committee on "Uniform Statistics of Sewer Construction and Maintenance" was appointed, showing that the intention from the beginning has been to take an active part in the extension of knowledge along sanitary lines. In the fifth annual report of the Executive Committee, presented March 4, 1908, the following will be found:

"In order to make the work of this Section valuable and keep up the interest, something should be done each year in the way of original research, for which the time and money should be provided. The committee hopes to see a fund made available for such work, by which these matters can be given the personal attention of some one, a member of the Section, who can be paid for his services."

In 1907 the Committee on Run-Off from Sewered Areas was appointed.

In 1908 a Committee on Collection and Tabulation of Sewerage Statistics was appointed to follow up the excellent work done by a former committee. The tabulations of statistics published by this committee have furnished valuable data to the profession. In this same year a committee was appointed to consider the subject of "Uniform Specifications for the Manufacture of Vitrified Sewer Pipe." This latter committee is still in existence, but owing to the desire to coöperate with a similar committee of the American Society for Testing Materials, it has been impossible to accomplish anything substantial in the way of progress.

Is it not time that additional work of this kind should be undertaken? There are many subjects of special interest which might properly be delegated to committee work, as, for example, —

Methods of assessing the cost of sewers on abutting property owners.

Collection of data regarding the cost and methods of construction and experience in operation of submerged pipe lines for outfall sewers.

Collection of data on sanitation of factory and mill buildings and matters affecting industrial occupations.

Your committee is of the opinion that the Section should carefully consider the general question of research work by committees, and if feasible, undertake additional work along this line.

Respectfully submitted.

For the Executive Committee,

FRANK A. MARSTON, *Clerk.*

BINDING THE JOURNALS.

MEMBERS who wish the Secretary to attend to the binding of their numbers of the *Journal of the Association of Engineering Societies* are requested to send them to Room 715, Tremont Temple, Boston, before April 15.

Arrangements have been made by which members can have the two volumes bound in one for 70 cents, or each volume bound separately for 50 cents; the style of binding to be the same and uniform with that of former years. Mark clearly which way it is desired the binding should be done.

As this will probably be the last opportunity members will have to secure the binding of their Journals under the present arrangement, they are urged to send in all numbers of back volumes which they intend to have bound.

APPLICATIONS FOR MEMBERSHIP.

[April 6, 1914.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

CHAPMAN, BENJAMIN RUSSELL, Brockton, Mass. (Age 49, b. East Dennis, Mass.) Attended Brockton High School. 1883 to 1891, with Elbridge L. Brown, civil engineer and surveyor, who till 1888 was acting as town and city engineer (during this time first investigations were made for establishment of sewerage system); 1891 to 1898, with F. Herbert Snow, city engineer, during greater part of this period as assistant engineer in charge of designing and carrying out to its completion the abolition of grade crossings within city limits; 1898, city engineer of Brockton; 1898 to 1913, principal assistant to city engineer of Brockton, now city engineer of Brockton. Refers to F. A. Barbour, C. R. Felton, W. S. Johnson, J. W. Rollins, R. S. Weston, G. H. Wetherbee, Jr., and H. L. White.

DRISCOLL, JAMES MICHAEL, Brookline, Mass. (Age 39, b. Brookline, Mass.) Graduate of Massachusetts Institute of Technology, 1896, civil engineering course, degree of S.B.; 1896 to 1900, rodman and instrumentman with Metropolitan Water Board; 1900 to 1901, with U. S. N. as structural steel draftsman, at Portsmouth, N. H.; 1901 to 1902, hydrographic draftsman on board U. S. S. *Vixen*; 1902 to 1903, Survey Colorado Reefs, Cuba; 1903, private surveying and road work; 1904, structural draftsman, Charleston, S. C.; 1904 to date, superintendent and engineer, Holyhood Cemetery Association. Refers to H. F. Bryant, G. E. Harkness, G. E. Russell, H. A. Varney.

HAGGETT, HAROLD DANIEL, Allston, Mass. (Age 28, b. Bath, Me.) Graduate of University of Maine, 1909. August, 1909, to January, 1910, with Pennsylvania Railroad; January to June, 1910, with Boston Elevated Railroad; June, 1910, to date, with Boston & Maine Railroad; is now transitman in engineering department. Refers to B. W. Guppy, T. P. Perkins, J. J. Rourke and F. B. Rowell.

HAYWARD, EDWIN DANIEL, Bridgewater, Mass. (Age 22, b. Bridgewater, Mass.) From 1910 to date, student at Massachusetts Institute of Technology, civil engineering course. Refers to C. F. Allen, A. E. Burton, A. G. Robbins and C. M. Spofford.

LAWRENCE, BEARDSLEY, Dorchester, Mass. (Age 26, b. Short Hills, N. J.) Student at Massachusetts Institute of Technology, civil engineering course, 1907 to 1909 (one and one-half years). June to October, 1909, rodman with Charles River Basin Commission; October, 1909, to May, 1912, rodman and instrumentman with Metropolitan Water and Sewerage Board; May to December, 1912, engineer with San Domingo Light and Power Company, Santiago, San Domingo; December, 1912, to date, instrumentman with Metropolitan Water and Sewerage Board. Elected a junior, October 16, 1912, and now desires to be transferred to grade of member. Refers to J. N. Ferguson, C. F. Fitz, Jr., Clifford Foss, W. E. Foss and B. A. Rich.

MANN, OSWELL F., Somerville, Mass. (Age 33, b. Brockton, Mass.) Graduate of English High School, 1897. With E. G. Mann one and one-half years; 1899 to 1903, with E. Harrington & Co.; December, 1903, to May, 1904, on appraisal work with Gilbert Hodges; 1904 to date, with Edison Electric Illuminating Company of Boston; is at present head of Conduit

Division, Street Engineering Department. Refers to R. E. Curtis, G. D. Emerson, F. A. Snow and S. E. Tinkham.

MORROW, CLARENCE EDGAR, Boston, Mass. (Age 25, b. Columbus, Ohio.) Graduate of Whitman College in 1910 and of Massachusetts Institute of Technology, architectural engineering course, in 1912. June to September, 1909, 1910 and 1912, with Gilbert Hunt Company, Walla Walla, Wash., first summer as machinist, second as assistant foreman in fabrication shop, third as draftsman; June to September, 1913, engineer, with W. W. Bosworth, architect, New York City; September, 1912, to date, instructor in Architectural Engineering at Massachusetts Institute of Technology; November to December, 1913, with Prof. C. M. Spofford on design of Chelsea Bridge, South; January, 1914, to date, with Stone & Webster (Cambridge office), mornings, as structural engineer. Refers to W. W. Clifford, W. H. Lawrence, E. F. Rockwood and C. M. Spofford.

NICHOLS, CHARLES ELIOT, Watertown, Mass. (Age 29, b. Somerville, Mass.) Received degree of A.B. from Harvard College, 1907; student for two years in structural engineering at Harvard Graduate School of Applied Science. 1910 and 1911, draftsman and designer in Seattle, Wash., and Portland, Ore., with Stone & Webster Engineering Corporation, and with Doyle, Patterson & Beach, architects; February, 1912, to date, with Stone & Webster Engineering Corporation on following work: to October, 1912, designer on station of Mississippi River Power Company at Keokuk, Ia.; October, 1912, to April, 1913, inspector and field engineer at power house of Boston Woven Hose & Rubber Co.; April to October, 1913, in charge of drafting and designing of concrete construction in Boston office; October, 1913, to date, structural engineer in charge of design of new Massachusetts Institute of Technology buildings at Cambridge. Refers to H. K. Alden, W. W. Clifford, L. J. Johnson, Mark Linenthal, W. N. Patten, E. F. Rockwood and S. E. Thompson.

SABIN, FRED DEXTER, Somerville, Mass. (Age 28, b. Meadville, Pa.) Professional education obtained at Lawrence Scientific School and Harvard University. 1902 to 1904, rodman and transitman with engineering department, city of Cambridge; 1904 to 1906, at college; 1906 to 1907, transitman with engineering department, city of Cambridge; dredging inspector with Massachusetts Harbor and Land Commission (two months); 1907 to date, resident engineer with Massachusetts Highway Commission. Refers to G. F. Hooker, A. M. Lovis, A. E. Tarbell and R. A. Vesper.

SHERMAN, HERBERT L., Belmont, Mass. (Age 32, b. Kingston, Mass.) Graduate of Massachusetts Institute of Technology, 1902, in chemistry. From graduation till 1904, assistant in mineralogy at Massachusetts Institute of Technology, chemist with Massachusetts State Board of Health, chemist with Helderberg Cement Company, and cement tester with United Shoe Machinery Co.; 1904 to 1914, has conducted business of industrial and engineering chemist, specializing in cement and concrete, in Boston; has just been instrumental in forming New England Bureau of Tests, of which he is

president, engaged in general inspection, testing and analysis of all commercial products, with branch laboratories in all the mill districts. Refers to J. N. Ferguson, F. W. Hodgdon, C. T. Main, C. W. Sherman, E. C. Sherman and J. R. Worcester.

WARING, CHARLES THOMAS, Sandwich, Mass. (Age 37, b. Philipsburg, Pa.) Graduate of Philipsburg High School; 1893 to 1896, engaged in private study with A. V. Hoyt, civil engineer. With Isthmian Canal Commission, first as rodman to assistant engineer in charge of Residency Division of Municipal Engineering, April, 1905, to November, 1908; then as assistant engineer in charge of general surveys, Third Division of Office of Chief Engineer, 1908 to 1909; with Cape Cod Construction Company, as division engineer, November, 1909, to March, 1912; as resident engineer, March, 1912, to date. Refers to H. S. Adams, H. W. Durham, F. W. Hodgdon, J. W. Rollins, C. M. Saville and W. F. Williams.

EMPLOYMENT BUREAU.

THE Board of Government has established an employment bureau for the Society, to be a medium for securing positions for its members and applicants for membership, and also for furnishing employees to members and others desiring men capable of filling responsible positions.

At the Society room two lists are kept on file, one of *positions available* and the other of *men available*, giving in each case detailed information in relation thereto.

MEN AVAILABLE.

221. Age 21. Graduate of Mechanics Arts High School, 1911; now third-year student in civil engineering course at Massachusetts Institute of Technology. Has had one summer's experience doing field work in plane, topographical and hydrographic surveying, as well as railroad field work at M. I. T. summer surveying camp; has had considerable experience as a chauffeur. Desires position as instrumentman for the summer.

222. Age 26. Graduate of Massachusetts Institute of Technology, 1911, in electrical engineering course. Has had five seasons' experience as theater electrician; was with General Electric Company Lamp Works, Harrison, N. J., for eight months; has been two years with Standard Plunger Elevator Company, Worcester, Mass., as chief estimating engineer. Desires position in any line of engineering work for which this experience qualifies him.

223. Age 43. Had four years' special course in civil engineering at Massachusetts Institute of Technology. Has had fifteen years' experience on land and topographical surveys, location, design and construction of roads,

and plain and reinforced concrete walls and bridges; five years' experience in charge of heavy excavation and aqueduct construction. Desires position in charge of concrete construction or road building. Salary desired, \$150 per month.

224. Age 42. Graduate of Massachusetts Institute of Technology in electrical engineering, class of 1894. Has had seventeen years' experience in charge of electric lighting plant of Lonsdale Company, cotton manufacturers, Lonsdale, R. I.; January, 1913, engaged by Boston & Providence Railroad Corporation, as assistant engineer, representing their interests in proposed four-tracking and electrification of their road by New Haven Railroad, which work has been indefinitely postponed. Desires position along electrical and mechanical lines, either construction or operation. Salary dependent upon position and future prospects.

225. Age 18. High school graduate and student for one half-year at Massachusetts Institute of Technology. Has had one summer's experience as rodman on topographic work, with H. F. Bryant, Brookline, Mass. Is willing to accept any position that will give him experience along engineering lines.

226. Age 19. Student at Phillips-Exeter Academy for two years and at Dartmouth College two and one-half years; at present student at Massachusetts Institute of Technology. Has worked for several summers with different engineers, but mostly with H. M. McIntosh, civil engineer, Burlington, Vt. Desires position as rodman or transitman. Salary desired, \$12 to \$15 per week.

227. Age 37. Has had ten years' experience on various state commissions and on municipal work; for past five years has been assistant engineer, principally on design and construction of sewerage systems. Salary desired, \$125 per month.

POSITION AVAILABLE

Rodman wanted on state highway work. Man having knowledge of use of transit and principles of drafting preferred. Salary \$60 per month and expenses in field.

LIST OF MEMBERS.

ADDITIONS.

BILDT, A. FREDRIK.....1182 Harrison Ave., Roxbury, Mass.
GARTLAND, EDWARD VINCENT.....20 Roslin St., Dorchester, Mass.

CHANGES OF ADDRESS.

BURDEN, HARRY P.....	60 Lewis St., East Lynn, Mass.
CLAPP, WILFRED A.....	68 Ramona Ave., Oakland, Cal.
COBURN, HOWARD L.....	61 Broadway, New York, N. Y.
DUTTON, CHARLES H., care J. R. Worcester & Co.,	79 Milk St., Boston, Mass.
EGLEE, CHARLES H.....	8 Beacon St., Boston, Mass.
EMERSON, RALPH W.....	20 Boylston St., Pittsfield, Mass.
FOX, SAMUEL, JR.....	93 Newbury St., Boston, Mass.
HALL, HARRY R.....	16 West Saratoga St., Baltimore, Md.
HOWE, EDWARD W.....	26 Wayne St., Roxbury, Mass.
JOHNSON, FRANK W., care Ambursen Co.	61 Broadway, New York, N. Y.
KIDD, ALEXANDER L.....	43 Sagamore St., Dorchester, Mass.
KIMBALL, ERNEST R.....	40 Upland Road, Arlington, Mass.
TIBBETTS, FRED E.....	125 Liberty Road, W. Somerville, Mass.

RESIGNATIONS.

(In effect March 18, 1914.)

BALDWIN, THOMAS A.	PHELPS, EARLE B.
BIGELOW, JAMES F.	RANSOM, HORACE U.
CHISHOLM, IVAN A. F.	RICHARDS, WALTER H.
CHURCH, WILLIAM L.	ROBINSON, WALTER F.
FRENCH, EDMUND M.	TREFETHEN, ERNEST M.
HANSEN, PAUL	WATSON, WILLIAM
HOWE, GEORGE E.	WETHERBEE, GEORGE A.
HYDE, CHARLES G.	WHITE, GEORGE V.
PITMAN, LAWRENCE M.	WHITNEY, GEORGE E.

LIBRARY NOTES.

RECENT ADDITIONS TO THE LIBRARY.

U. S. Government Reports.

Annual Reports of Chief of Engineers of War Department, Vols. 4, 5 and 6 for 1897, and Vol. 1 for 1898. Gift of E. H. Rogers.

Forest Tree Diseases Common in California and Nevada. E. P. Meinecke.

Fuel-Briquetting Investigations, 1904-12. C. L. Wright.

State Reports.

Maine. Annual Reports of Railroad Commissioners for 1906, 1908, and 1910-13 inclusive.

Ohio. Wood-Using Industries, 1912. Carroll W. Dunning.

County Reports.

Essex County, Mass. Annual Report of County Engineer for 1913.

City and Town Reports.

Cambridge, Mass. Annual Report of City Engineer for 1912-13.

New York, N. Y. Preliminary Reports on Sewage Disposal, XI-XIV inclusive.

Northampton, Mass. Annual Report of Water Commissioners for 1913.

Peabody, Mass. Annual Report of Commission of Public Works for 1913.

Providence, R. I. Annual Report of City Engineer for 1912.

Providence, R. I. Annual Report of Department of Public Works for 1913.

Reading, Mass. Annual Report of Water Commissioners for 1913.

Rutland, Vt. Annual Report of City Officers for 1913.

Wellesley, Mass. Annual Report of Water and Light Commissioners for 1913.

Miscellaneous.

Bridges of Cleveland. Henry Grattan Tyrrell.

Canada, Dept. of Mines. Annual Report on Mineral Production of Canada for 1912. Preliminary Report on Mineral Production of Canada for 1913.

Esthetic Treatment of City Bridges. Henry Grattan Tyrrell.

Naval Architects and Marine Engineers: Transactions for 1909.

Recall of Constitutional Safeguards. Rome G. Brown.

Trussed Concrete Steel Co. Hy-Rib Concrete Silos and Farm Buildings, 5th ed.

We have been unable to procure from headquarters a copy of the Annual Report of the Railroad Commissioners of the State of Maine for 1909, which is the only volume now needed to make our file complete. Can any one of our members supply us with a copy?

LIBRARY COMMITTEE.

NEW ENGINEERING WORK.

(Under this head a brief description of new engineering work contemplated or under construction will be presented each month. Engineers and contractors are requested to send descriptions of their work to the Secretary, 715 Tremont Temple, Boston, before the 25th of each month.)

United States Government. — **NAVY DEPARTMENT.** — *Navy Yard, Boston.* — Work is now in progress or new work is contemplated as follows:

WORK IN PROGRESS.

Mold loft floor for new supply ship.

Timber wharf extension at Naval Magazine, Hingham.

Reconstruction of Building No. 24: reinforced concrete.

Remodeling Building No. 77 for use as boat storage, including equipment with crane service.

Two 300-ft. radio towers on Naval Hospital Reservation, Chelsea. (Contract let.)

Building for central heating plant, Naval Hospital, Chelsea, to be built by day labor.

NEW WORK CONTEMPLATED.

Fireproof floor, sprinkler system and metal storage racks, pattern shop, Building No. 42.

Building ways for construction of new supply ship.

Commonwealth of Massachusetts. — **METROPOLITAN PARK COMMISSION.** — *Woburn Parkway.* — Work of construction of Woburn Parkway is in progress.

Charles River Reservation, Lower Basin. — Work of construction of retaining wall along Broad Canal on property of Horgan Estate is in progress.

DIRECTORS OF THE PORT OF BOSTON. — *Dry Dock.* — Office force working on plans and H. P. Converse & Co. constructing bulkhead.

Viaduct. — Steel work completed.

Railroad Yard. — Contractor shipping material for the work.

Heating Plant. — Nearly completed.

Commonwealth Pier No. 5. — Contractor at work on Head-house.

Commonwealth Pier No. 1. — Office force at work on plans. Old pier being removed. Dredging partly done.

MASSACHUSETTS HIGHWAY COMMISSION. — A three-span reinforced concrete arch bridge is under construction at Onset between Onset and Point Independence in Wareham. One abutment and three piers are completed. Work now being done on second abutment and one arch. Forms are practically completed for arch, and concrete will be placed during week of March 30, weather permitting.

Revere Traffic Road, extending from Point of Pines southerly to Revere St., including bridge over Boston, Revere Beach & Lynn R. R., and Boston & Maine R. R., is now under construction. Steel bridge with concrete floor is to be placed during month of May. The road surface is to consist of broken stone, bound with tar by the penetration method.

A reinforced concrete arch bridge is being constructed in Blackstone in connection with a bituminous macadam road surface about one and one-half miles in length.

METROPOLITAN WATER AND SEWERAGE BOARD. — *Sewerage Works.* — Work on Sections 69 and 70, new Mystic Sewer, at Winchester, is in progress.

Boston Transit Commission. — *Boylston Street Subway and Dorchester Tunnel.* — No change since last report as printed in the March JOURNAL.

East Boston Tunnel Extension. — Section G. — No change since last reports except that the work of underpinning the

buildings east of Cornhill has begun. Isaac Blair & Company, Inc., is the contractor.

Section H is located in and near Court and Cambridge Sts., extends from Stoddard St. to Staniford St., and includes the Bowdoin Square station. The structure is to be mainly of reinforced concrete with steel columns and roof beams for a portion of the way. The contract has been awarded to Coleman Bros., and the work has been started.

Section J extends from Staniford St. to North Russell St. The incline in Cambridge St. between Chambers St. and North Russell St. has been built. Excavation is proceeding between Staniford and Chambers streets. The walls of the tunnel are partly built and a considerable portion of the roof has been placed in this vicinity. Coleman Bros. are the contractors.

City of Boston.—PUBLIC WORKS DEPARTMENT, SEWER AND WATER DIVISION.—*Sewer Service.*—The following work is in progress:

Mattapan Brook between Norfolk and Delhi Sts., Mattapan. 5 ft. 6 in. concrete conduit; 15-in. pipe supplementary sewer. Rock cut. Haines-Weaver mixer at work on this job.

Spring St. Brook between Summer and Centre Sts., West Roxbury. American Vitrified Segment Sewer block being used on this job; 5 ft. 3 in.

Albany St. at Union Park St., South End. Double concrete conduit being built on piles. Size, 4 ft. 10 in. x 10 ft. 6 in., together with 2 ft. 9 in. x 10 ft. 6 in.

Aberthaw Construction Company.—At South Boston, at the end of the Fish Pier, the Aberthaw Construction Company is putting up the steel frame and concrete buildings for the Commonwealth Ice and Cold Storage Company. The power house and machinery building have been completed. The foundations are complete on the main cold storage building and the ice wing is framed in and the concrete work started. The most interesting features of the job are the contractor's methods of handling work on a task and bonus basis. This they would be glad to show any member of the Society that cares to visit the

work. The method of handling fairly high concrete buildings during winter weather is worth examination.

The Fore River Shipbuilding Co., Quincy, Mass., has the following new work in progress:

U. S. Battleship *Nevada*.

U. S. Submarine Tender *Fulton*.

Nine U. S. submarine boats.

U. S. Torpedo Boat Destroyers *Cushing* and *No. 57*.

BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PAPERS AND DISCUSSIONS

This Society is not responsible for any statement made or opinion expressed in its publications

BOSTON FOUNDATIONS. DISCUSSION.

BY MESSRS. CHARLES R. GOW, L. M. HASTINGS, F. P. STEARNS,
E. W. HOWE, H. F. BRYANT, HENRY S. ADAMS, RALPH E. RICE,
CHARLES T. MAIN, F. H. CARTER, C. T. FERNALD,
H. E. SAWTELL, L. W. TUCKER AND
GRANVILLE JOHNSON.

CHARLES R. GOW (*by letter*). — The permanent value of Mr. Worcester's paper will be keenly appreciated by all engineers and architects who have to do with the details of foundation construction in this locality.

A most extended discussion of its features would seem to be desirable at this time, since, unless the author sees fit in the light of such discussion to modify the conclusions tentatively set forth, they will stand, and justly so, as the most authoritative opinions, on the subjects treated, at present available for this locality.

The desirability of adopting some standardization of practice in foundation requirements as suggested by the author has been long apparent to the writer. A marked divergence of views among engineers and architects as to proper allowances and methods in their design and construction has, in many instances, seemed to lead to unnecessary waste of expenditure, while in other cases a boldness has been shown bordering upon recklessness. It is probably fortunate and to the credit

NOTE. Further discussion of this paper is invited, to be received by Edward C. Sherman, Editor, 6 Beacon Street, Boston, before May 10, 1914, for publication in a subsequent number of the JOURNAL.

of the profession that the former type has greatly outnumbered the latter.

Perhaps the most interesting of the author's recommendations are those referring to allowable unit loads on the various soils. The actual loading tests recorded in the paper are, as the author states, probably too few to form a basis from which to draw positive conclusions, but are, nevertheless, of great assistance in arriving at a determination of what may be safe limits for the given localities.

In addition to the tests reported, the writer is able to add the partial results of two such tests now under observation. These were undertaken by the writer in connection with some studies he was making for Prof. W. O. Crosby, of the Massachusetts Institute of Technology, on the sub-soil characteristics at the new Technology grounds in Cambridge. The site was filled to a depth of eight to ten feet with material pumped from the Charles River some years ago. Below this filling there is a deposit of silt and peat to a further depth of eight to ten feet which rests upon a stratum of gravel varying in thickness from ten to twenty feet. Under the gravel is a deposit of soft blue clay extending down to the bed rock or hardpan at a total depth of from one hundred to one hundred and twenty feet.

One loading test was made to determine the bearing value of the gravel stratum and a second to ascertain the supporting power of the clay. The tests were applied as follows: Excavation by means of 3-ft. diameter steel cylinders was carried down to the gravel at a depth of 20 ft., and in the second case to the clay at a depth of about 30 ft.; a wooden box 12 in. square on the inside, with open ends and of sufficient length to reach from the surface to the bottom of the excavation, was lowered into the shaft and erected in its center in a vertical position, a cast-iron plate 12 in. square having previously been bedded on the soil to be tested, around which the lower end of the 12-in. box fitted; a 10-in. by 10-in. post was lowered through the vertical box with its lower end resting upon the 12-in. cast-iron plate and with its upper end projecting above ground to a sufficient height to permit of a platform box being constructed around it; this loading box was partially filled with a cheap concrete weighing

135 lb. per cubic foot. Previous to inserting the post the space between the 12-in. box and the sides of the 3-ft. shaft was back-filled and the cylinders removed, leaving the vertical 12-in. box buried in the ground for its full length.

Owing, probably, to the imperfect bedding of the 12-in. cast-iron plates on the underlying soil, there was in the case of each test an initial reading of one inch of settlement when the load was applied, but no further settlement has occurred, although the load on the gravel was later materially increased and both tests have now been under observation for more than nine months.

The initial load applied on the gravel was five tons, which load was increased at the end of nine days to eight and one-half tons with no resulting settlement. The load on the clay test was five tons and, with the exception of the initial settlement referred to, has shown no further yielding up to the time of last reading. It should be stated that the clay at this particular spot was of medium hardness. It is hoped that observations can be continued on these two tests for at least another year.

The writer is pleased to find the author of this paper recommending somewhat higher unit loads than have heretofore been considered permissible. The suggestion that the stiff clays and hardpans are perfectly safe under unit loads of six tons is in accord with the writer's experience, and he has at times adopted values as high as eight tons for the cemented clays and gravels with no unsatisfactory results. The adoption of higher values for sand seems well justified in the light of experience, although many designers still hesitate to permit as high loading on sand as on the clays. There seems to be no logical reason for discriminating against the coarse sands in favor of clay as a foundation material since the evidence appears to show sand to be the superior of the two as regards ability to support and distribute applied loads without settlement. Undoubtedly this prejudice, where it exists, is often due to a fear of future disturbance of the underlying soil in case other excavations are made in the vicinity. The fact is, however, that the plastic clays are much more susceptible in this respect than are the coarse sands even when they are water-bearing. The explanation of this lies in the well-known tendency of the clays to shrink in volume when

exposed to the drying action of air. Ordinary plastic blue clay contains a large percentage of moisture, stated by some to be at least 20 per cent. by volume. The extraction of this moisture or any appreciable portion of it will cause a corresponding decrease in bulk of the surrounding clay. The result of this action is usually a subsidence of the surrounding soil and consequent settlement of such structures as may be supported by it. Thus in the construction of the East Boston Tunnel it was found that during the construction of that portion built by tunnel methods in lower State Street, the initial settlement was observed in the surface of the street when the work had approached not less than 75 ft. from the point observed, although the work was carried on by the compressed air process and absolutely no ground was lost. The same phenomenon was noticed during the sinking of the pneumatic caissons for the new Custom House tower, in which case the old building was badly damaged by extensive settlements.

It will be argued by many that the extraction of the water from sand will cause a similar action, but the writer has serious doubts as to the accuracy of this assumption unless some sand is also drawn with the water. There is no better known method of consolidating sand than that of immersing it in water, and if the grains are then in a position of maximum proximity it is difficult to understand how the withdrawal of the water from the voids of the sand can bring the particles into any closer relation. It has sometimes been argued that the water in the sand exerts an upward supporting pressure, but this is manifestly impossible since the pressure at the surface of the water must be zero, and at any deeper point the upward and downward pressures will balance each other. It may be that in the case of great loads carried on comparatively small areas, a lateral displacement may result, due to adjacent excavations, but the same result in a more pronounced form may be expected if the material is clay.

The author's recommendation that soft clays be limited to unit pressures of not more than $2\frac{1}{2}$ tons would seem to be liberal, though probably well within the limits of safety, but fine or running sands which are included under the same recommendation would seem to be entitled to somewhat higher values. In view of the common conception of this material, however,

this suggested limit will not be generally regarded as over-conservative.

The treatment of the questions relating to the safe supporting power of piles adds very materially to the present knowledge on the subject. There is, however, some doubt in the mind of the writer as to the wisdom of increasing the value of the *Engineering News* formula by 50 per cent. It should be borne in mind that test piles are apt to be driven with greater care than is ordinarily used, and that results obtained from them may not represent an average. If then, as stated, the value of C appears to be about 4 for settlements of $\frac{1}{4}$ in. in the several tests reported, the adoption of the constant 3 as suggested allows but a small safety factor under the most favorable conditions.

The more or less general adoption in this locality of ten tons per pile as a safe load for spruce piles well driven has proved reasonably satisfactory, and failures of pile foundations have been decidedly uncommon. It may well be, therefore, that we can afford to profit by this experience and adopt more liberal factors in our formulas. Undoubtedly, no set formulas will give uniformly satisfactory results in all cases, and they cannot be expected to replace altogether the good judgment and common sense which, after all, are the most essential requisites for good work of this class. There are probably many more piles seriously damaged by overdriving than were ever left in an unsafe condition due to underdriving. Too often the inspector is content to watch the pile head settle under the successive blows of the hammer without any concern as to what may be happening at the point. There is seldom any difficulty in driving spruce piles into clay even to a considerable depth, and the same is true in some sands. When, however, it is necessary to drive through gravel, it is doubtful if spruce piles can be made to give satisfactory results. It has been the writer's experience that only a small percentage of such piles ever get through gravel to any appreciable depth without showing evidences of breakage, either above or below the ground. Under such conditions oak piles may give much better results, but in very coarse material it is doubtful if even they will always answer the requirements. Under some conditions the water jet is an aid to overcoming

this difficulty, and it has been used most effectively in many instances.

Regarding the allowable point of cut-off, it is difficult to see how any fixed grade can be adopted with safety for all localities without being unnecessarily low for some of them. There is unquestionably a tendency for ground waters in this locality to seek lower levels than those formally held. This may be due to various causes, but it is somewhat disquieting to feel that the water level of to-day may be considerably above that of the future in localities where we are relying on its preservative effect in maintaining the integrity of wooden piles.

As to the influence of the Charles River Basin on the ground-water level of the Back Bay district, it should be noted that the marginal conduit as constructed forms a more or less effective cofferdam, shutting off the admission of water from the basin to the land between Charlesgate East on the south and the Charles River Dam on the north. This effect results from the fact that the conduit was constructed within water-tight sheet pile cofferdams which were continuous and were left in place after construction. This piling was driven through the water-bearing seams to the impervious clay below, and upon completion of the conduit the entire area was filled over with a miscellaneous assortment of filling. There would seem to be no good reason why such a structure should not effectually prevent the access of the water in the basin to that portion of the land immediately in its rear. Added to this result is the exclusion of the tide which formerly entered the district through the old sewers and which the new conduit now effectively excludes by means of modern tide gates. It is true that an attempt has been made to introduce water from the basin by means of pipes laid over the top of the marginal conduit and discharging into the vicinity of the old sea wall which formerly marked the boundary between the river and the land. The writer does not understand that this expedient has been entirely successful in reëstablishing the former level of the ground water, although it has had some local influence.

Some years ago the writer's firm made some seven borings for the Charles River Basin Commission, scattered along this

territory referred to, for the purpose of observing the fluctuations of the water levels, and the casings have been allowed to remain in place since for the purpose of continuing the observations. It has been found that in some cases the water has stood as low as grade 3.00,* and in none of the pipes adjacent to the basin has it risen to grade 8.00.* A marked fluctuation has been noted in each case, and the influence of the pipes mentioned above has had an appreciable effect in some instances, but the fact remains that at the present time the water in these borings does not average above grade 6.00.

There is strong evidence to the effect that the leaching action of the sewers accounts for some of the depression of water level, but that this effect should be so general will probably be surprising to many. Readings have also been taken from time to time on the water levels in two old borings on Commonwealth Avenue at Dartmouth and at Arlington streets, and it has in general been found to average lower than grade 8.00, although rising somewhat higher than that at times.

When the writer's firm made the preliminary borings for the Boylston Street Subway, frequent tests of the water level showed it to be almost uniformly at grade 8.00. On the other hand, the writer has found the ground water to stand at grade 5.00 at Stuart Street near Berkeley Street and at grade 6.00 at the junction of Beacon Street and Commonwealth Avenue. The Transit Commission engineers report finding great volumes of water on Dorchester Avenue in test pits sunk by them, which water rose only to grade 3.00. This water was reported as fresh even though occurring within only a few hundred feet of the South Bay, which is subject to the full tidal action.

It should be said in connection with the case referred to on Stuart Street, that although the water stood at grade 5, the old piles which were uncovered had been cut at grade 6.00 and were fully saturated, evidently by capillary action, and were in excellent condition.

There is some reason to believe that not all of the depressions of water levels recorded are due to leaky sewers, for, in the higher portions of the city, there has been noticed a tendency for the

* Referred to Boston Base, which is 0.64 ft. below mean low tide.

ground water level permanently to subside to elevations much below the adjacent sewers. Many instances could be mentioned in which localities that were once found wet at given depths were later found absolutely dry at much greater depths. The writer has always entertained the belief that this lowering was due to the continual increase in the number of deep wells that are being installed from time to time for commercial purposes and that although the water is in general drawn from great depths, it is quite possible that the porous strata used for the purpose may reasonably be expected to connect by means of seams and fissures with the higher strata. While it may not seem logical to many that even such districts as that of the Back Bay, for example, might connect with the underground sources of deep wells, it must be admitted that such water is often found brackish in character, indicating the possibility of such a connection.

In view of the possibilities pointed out above, the writer feels that it may prove to be unwise to deviate from the former practice of cutting at grade 5.00. He has found piles completely decayed at grade 8.00 at E and Second streets, South Boston, at which point the water level was apparently only slightly lower.

While speaking on the subject of piling, the writer desires to raise two points which seem to him to deserve discussion in this connection.

The first question relates to the desirability of stopping the points of piles in the harder crusts when they overlie softer strata, assuming that there is no filling, mud or peat below the pile point where so stopped. In many instances it will be found that piles drive very hard through some of the upper strata, developing resistances which indicate satisfactory supporting power, but after penetrating this crust they will often fail entirely to bring up with the required minimum penetration. Considering that the layer of soil at the level of the pile point must in any event carry the weight which is transmitted to it by the distributing effect of friction on the superficial area of the pile, it follows that the greater the distribution the more load it will sustain. The superior resistance of the hard crusts would seem to indicate wider angles of distribution of the load over the un-

derlying material and a consequent lessening of the unit load upon it. Under such conditions there would seem to be no great advantage in driving into the softer soils as is often required.

The second question relates to the practice of adopting single rows of piles under walls or of single piles under piers. Under ordinary conditions of driving it is seldom possible to bring the pile heads to the exact position desired, with the result that the center of load will be eccentric with the pile, if not entirely off of it. Any influences that tend to induce lateral movement of the supported load will then meet with little or no resistance against rotation about the pile head. It is often argued that piers supported on a single pile or upon a pair of piles can be secured against lateral motion by the tying effect of basement floors. As a caution against this assumption it should be remembered that piles are only necessary as a rule when the soil at grade is unstable, and that under such conditions, a basement floor laid on this soil is subject to settlement and cracking which may render it of no effect as a lateral support. The writer feels that no structure of a permanent character should be made to depend for its stability upon single rows of piling and that piers should rest upon not less than three piles arranged in the form of a triangle. The additional expense necessary to insure safety in this respect will not often be so material as to warrant the possibility of jeopardizing the future safety of the structure.

The danger which the author points out in the case of floors constructed directly upon fill overlying silt or peat is timely and should be considered in all designs where this condition exists. The silts and peats are highly compressible on account of the large amount of decomposed vegetable matter they contain. In their original state of deposit they are semi-fluid and possess no sustaining power. As the accumulations increase in depth the bottom layers are slightly compressed by the greater weight upon them, and when after a lapse of many years they have grown to considerable depths and have in many instances been loaded by the deposit of filling over them, they become quite dense and develop a resistance sufficient to carry the loads that have compressed them, but no more. Any further application of load beyond what they have become accustomed

to carrying will almost invariably produce increased compression to a point where a new state of equilibrium is established.

It has become somewhat common practice in certain sections of the city where these deposits abound to construct buildings, often with no basements and with the ground floors supported on filling which has been deposited on the site to bring it to the floor grade. No matter how carefully this filling has been selected and placed, it must exert an increased pressure on the underlying silt or peat, with the result that the latter is further compressed and a settlement of the floor results. This settlement usually is not apparent for some time after the increased load is applied and is likely to continue for months before finally coming to rest. If the deposits of silt or peat vary in thickness over the lot, the settlement will also be uneven in amount. Even when the load applied is less than that formerly carried, settlements may result from the fact that the new load is transmitted to the unreliable materials in a different manner than was the old load. Under the most favorable circumstances it would seem that these materials should be avoided if possible as a support for any portion of a structure.

The numerous boring records compiled by the author constitute a most valuable reference in convenient form for ascertaining the character of soils that may be expected to be met with in different localities considered.

Prof. W. O. Crosby, in his very interesting article on the geological origin of the Boston Basin, published some years ago, pointed out his belief that the Charles River originally had an outlet into Old Harbor, Dorchester, and that the Merrimac River then flowed into it after passing through what are now the Mystic Lakes and Fresh Pond. The basis for this very interesting hypothesis was the fact that a maximum depression was found in the surface of the bed rock along this route, indicating that at some period in the pre-glacial ages this channel had been worn in the rock by a stream of water.

As tending to confirm this theory it is interesting to study the character of the soil along the route of this supposed pre-historic river. It will be found from a study of these boring records that at the site of the service station of the Edison Company,

on Massachusetts Avenue near Edward Everett Square, the mud was found to extend down to elevation -62 , at the corner of Harrison Avenue and Hunneman Street to -43 , at the corner of Ruggles and Westminster streets to -45 , and at the corner of Riverdale Road and Station Street, Brookline, to -39 . If these points are located on a map and connected by a line, it will be found to correspond very closely with the suggested location of this pre-historic stream.

The assumed course of this old stream was shown in the article referred to deflecting to the northward from the last-named point, and we likewise find traces of its former existence in the mud deposits in Longwood playground extending down to grade -20 , in Beacon Street near Amory Street extending to grade -26 , and in the vicinity of Brookline Street Bridge extending to grade -25 . The former course from this point is supposed to have coincided for some distance with the bed of the present Charles River, leaving it again at Allston where the river bends to the northward and passing across the northern portion of Allston and through the Mt. Auburn district to Fresh Pond. There are indications along this latter part of the route similar in nature to those mentioned above of frequent mud deposits of considerable depth, and Mr. L. M. Hastings, city engineer of Cambridge, has found such deposits also to the north of Fresh Pond.

It will be noticed that all of these locations are well inside of the original shore lines as we now understand them and that, therefore, this chain of pools must have at one time formed a part of an inland water course. It is reasonable to suppose that at more or less frequent intervals along the line of this former gorge or valley there was deposited, during the glacial period, the clays and drift which dammed the original river, leaving these frequent pools, which during the succeeding ages have been filled with the wash of the surrounding land that drained into them. Thus we may not expect to find this deep mud condition continuous throughout the entire length, and as a matter of fact we do not. It may well be kept in mind, however, when there is occasion to locate structures in the approximate vicinity of this line, that such conditions as those described above may be expected.

The author refers to a certain general subsidence of the section of Cambridge in the vicinity of Massachusetts Avenue and Albany Street which is said to have amounted to a maximum of two feet in the past ten years. It has been suggested that this action may possibly be explained by the dredging of the Charles River some seventeen years ago and the depositing of the dredged material on the flats, thereby adding to the weight over the soft clay and causing a sub-soil flow toward the river where the load had been lightened. This theory as an explanation is somewhat unsatisfactory for many reasons. Much of the area which has settled is not filled land and is at such a distance from the river that it could hardly be affected by such a condition. Moreover, the total displacement due to settlement must necessarily have caused a marked upheaval of the bed of the river near the Cambridge shore which in all probability would be apparent. Again, the observed subsidence is less at points adjacent to the river than elsewhere, and no lateral movement of the sea wall has resulted as might reasonably be expected if the sub-soil was flowing out from under it.

This section of the city was originally low in elevation and the larger portion has been reclaimed by filling. A large percentage of the area contains a bed of peat which in general overlies a stratum of fine sand and this in turn covers a deep deposit of soft blue clay.

A test boring made by the writer within the past few days near the junction of Albany and Portland streets where the observed settlement is a maximum shows the following condition: 9 ft. of filling, 7 ft. of peat, 9 ft. of fine gray sand, 118 ft. of soft blue clay of the approximate consistency of putty and at least 5 ft. of soft slate.

Mr. F. D. Smith, chief engineer of the sewer division, Metropolitan Water and Sewerage Board, has been good enough to have some new levels taken along the line of the metropolitan sewer in Portland and Albany streets and to give the writer the benefit of the results together with a statement of former readings. These records show that the maximum settlement of this sewer has been at a point near the junction of Portland and Albany streets and that its total amount since the sewer

was built in 1893 is 2.61 ft. below the theoretical grade. A total length of nearly a mile is affected to a greater or less extent.

It is apparent from the settlement records of this section of the sewer that the subsidence proceeded during the first 13.5 years at the average rate of 0.14 ft. per year at the point of maximum depression, that during the next twenty-two months it averaged only 0.08 ft. per year, that for the next year and a half the average per year was 0.11 ft., while for the past four years it seems to have averaged 0.10 ft. per year. While slight inaccuracies in taking these levels due to the strong flow in the sewer and to deposits on the bottom may make the above comparison of figures of little value, there is reason to believe that the rate of subsidence, while not materially checked even at this time, may be assumed to be somewhat lessened. The various records collected by Mr. Hastings also offer some hope of a future reduction in the rate of subsidence.

The great depth of the bed of soft clay at the point of maximum subsidence suggests a relation between the thickness of this layer and the amount of settlement. The action must clearly be attributed to a change in this stratum either in its position or in its composition. The latter theory seems to the writer to be the more attractive one, and he therefore suggests that since the volume of clay depends upon the amount of moisture it contains and as the relative hardness appears also to have a relation to its condition of saturation, if we can conceive of any action which will cause this soft clay to give up a portion of its moisture we can account for the observed decrease in its volume. It is perhaps possible that the vibrations of surface forces may be transmitted to this underlying clay in such a manner as to cause it to quake slightly, in which event there would be a tendency for any surplus water to come to the surface.

The present observed action is especially interesting as offering an explanation of other known settlements of areas which now seem to be at rest. Thus, when we find peat deposits at great depths below the marsh level, we may assume that such settlements as their presence indicates may reasonably have occurred during a comparatively short period of subsidence such as the one we are now discussing. This assumption is strengthened

by the known fact that the peat deposits are usually covered with a deposit of silt, proving that the vegetation was suddenly stopped by a rapid subsidence of the marsh level below the surface of the water. Had the subsidence been as gradual as that which we now assume it to be in general, there seems to be no good reason why the peat should not be continuous to the surface.

L. M. HASTINGS (*by letter*). — The determination of what may be a proper and safe foundation for an engineering structure, or a building, is one of the most important and sometimes one of the most difficult and perplexing of the many questions which an engineer is called upon to decide, and the two papers on the subject by Mr. Worcester have thrown much light upon it and will prove very valuable additions to engineering literature.

The presence of reliable and easily reached foundations, either bed rock or unyielding soil, in a locality where heavy and important structures are to be placed, at once simplifies the engineer's problem and reduces the cost of the structure itself. There is no doubt, for instance, that the presence of bed rock so near the surface of the ground, found in the larger part of New York City, has saved enormous sums of money in the lessened cost of foundations alone.

This is in marked contrast with the conditions found in many parts of Boston and its vicinity. An examination of the data given by Mr. Worcester in his paper, and any extended experience in designing foundations here, will show that nature has not been kind to us in this respect and that the demands of an ever-increasing population have brought about great changes in the physical conditions in this locality, which have introduced problems and difficulties which did not exist in the earlier days of our history. Great areas of low land, formerly marshes, or flats under water, have been reclaimed by filling on to the existing mud and silt, which in turn is usually underlaid with clay of varying degrees of hardness and often of great depth.

These conditions, which are so common in this vicinity, are especially difficult to deal with successfully even with the expenditure of large sums of money. This has been shown repeatedly in some of the large and expensive buildings, where in

spite of what was thought at the time to be ample provision for stable foundations, settlement has occurred.

The ever-increasing number, size and weight of buildings, bridges and other structures upon these areas render imperative the most careful and intelligent study of all the data which can be obtained bearing upon the case in hand. The supporting power of piles driven into soils such as have been referred to above seems to be one of the factors which is almost impossible of exact determination. Even if they are driven to a fairly hard resistance, unless deep borings have shown that the hard stratum is of sufficient thickness and stability to carry the load submitted to it by the piles, settlement may occur in time.

The comparatively recent practice of testing out the bearing power of a soil by test loads applied for a long time, and under conditions as nearly as possible analogous to those which will exist in the actual construction, has much to commend it. Fairly accurate results should usually be obtained by this method, certainly vastly more reliable than those obtained from any formula, or deductions made from wash borings, rod soundings or test pits.

But even this method has its limitation and may prove ineffective if the whole locality is gradually settling to a considerable depth, as seems to be the case in certain parts of Boston and Cambridge. It may be instructive to describe briefly some of the observed facts about this rather curious and interesting case in Cambridge.

The affected area is shown on Fig. 1, one axis extending along Massachusetts Avenue from Harvard Bridge to near Central Square, and the other from Albany Street, at Pacific Street, marked [10], to the junction of Portland Street and Broadway, marked [11]. Within this district noticeable settlements of the ground and buildings have occurred, the maximum being found near the junction of Portland and Albany streets. The metropolitan sewer, built largely of brick and 48 in. by 54 in. in dimensions, extends the entire length of both Albany and Portland streets and was built in the natural soil, largely sand, without piles, in 1893, at about elevation - 5.00.* A settlement in this

* Referred to Cambridge base.



FIG. 1. MAP OF A PART OF CAMBRIDGE.

sewer begins at about Pacific Street [10] and reaches a maximum at the point marked [8], where the sewer is now about 2.60 ft. below its original grade as laid in 1893. This settlement gradually diminishes toward the northeast until at point [11] the sewer is at its original grade.

Directly alongside the metropolitan sewer is one built by the city of Cambridge on piles in 1882 and at about elevation 5.00. At the point marked [16] in Albany Street, this sewer has settled about 3.00 ft. from its original grade.

The brick building of the Metropolitan Storage Warehouse Company, marked [9], and built upon a pile foundation, is now 1.18 ft. lower than it was in 1897. The Odd Fellows Hall building, of brick, placed upon a natural sand foundation 10 to 12 ft. below the surface, marked [2], has, since 1898, settled 0.82 ft. The brick building at the junction of Main Street and Massachusetts Avenue, marked [5], built without piles on sand, has settled 1.30 ft. since 1898. The two points on the sea wall at [12] and [13], and most of the wall between, show very little settlement but, at one point, where an old creek entered the river, the wall has settled more than a foot.

Numerous other points have been observed, all tending to show that the settlement diminishes from the maxima at [8] and [16] to the boundaries of the district.

Fig. 2 is a profile on the line of Massachusetts Avenue to the Boston & Albany Railroad and thence produced southeasterly to the river channel, compiled from such data as were available.

This shows that a deep bed of clay underlies the surface materials, and extends to bedrock. Much of this clay was found in the borings to be soft and putty like. The surface materials are filling, mud, sand and gravel.

The area between the sea wall and the Boston & Albany Railroad was filled largely by hydraulic dredging from the river flats. These flats were excavated to a level about 20 ft. below mean high tide, or about 10 ft. below the surface of the flats. Upon the tract northwest of the Boston & Albany Railroad, much of the land has been raised somewhat in grade by filling, and many large and heavy buildings for factory and other pur-

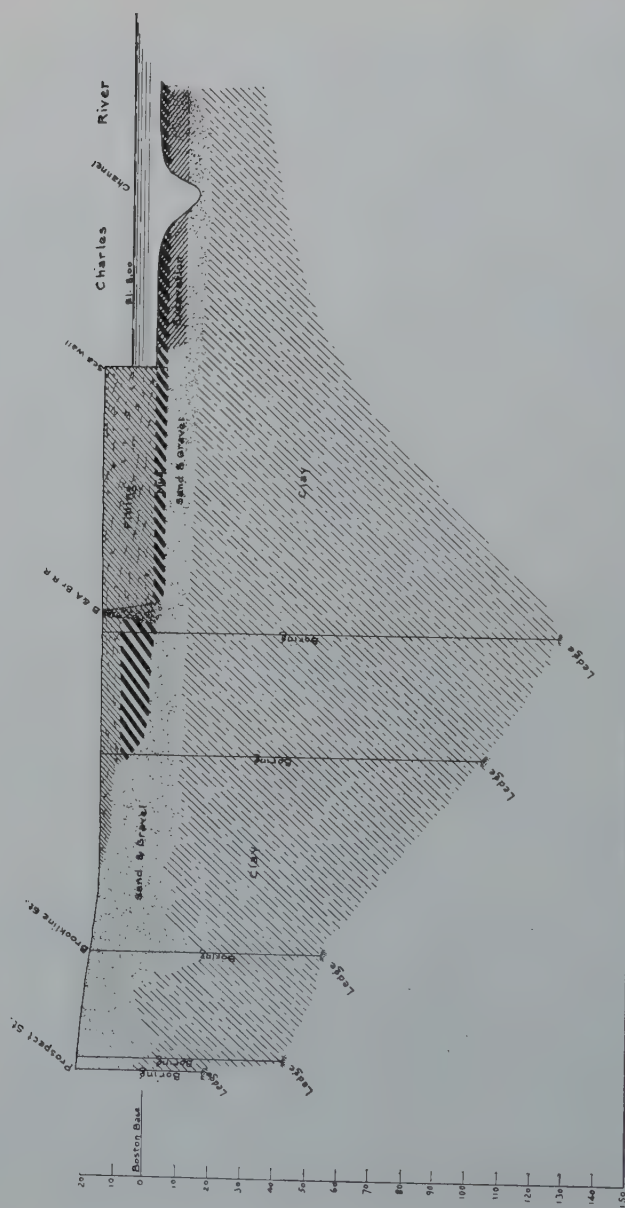


FIG. 2. PROFILE ON MASSACHUSETTS AVE.

poses have been erected in the last fifteen years, while traffic on the streets has correspondingly increased.

To explain the movement as observed above, two theories suggest themselves, neither of which is entirely satisfactory. The first and more obvious one is that the increased weight upon

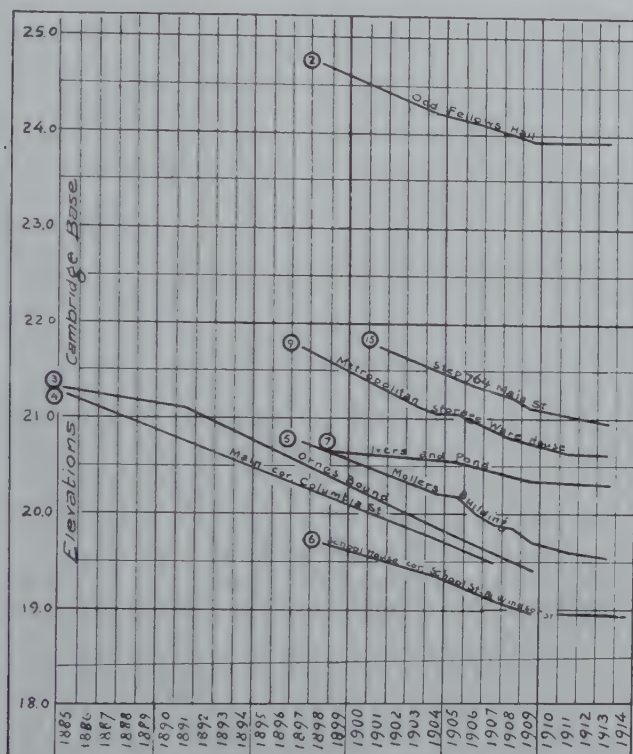


FIG. 3. DIAGRAM SHOWING RATES OF SETTLEMENT OF POINTS IN CAMBRIDGE.

the area occasioned by filling, buildings and street pavements, with the impact of traffic, cars, etc., has caused progressive compression of the underlying clay stratum which shows itself by the settling of surfaces and structures whether carried on piles or not.

The lack of movement at [12] and [13] and at other points

between them might be partly explained by the fact that the material there is somewhat harder than elsewhere.

It seems difficult to reconcile this theory with the behavior of the roadbed of the Boston & Albany Railroad. This road was built about 1860 upon a heavy fill across the flats and marsh, and the point of maximum settlement at [16] is within 200 ft. of the road. Since its construction this road has been in operation as a freight road entirely. It would be expected that the limit of compression due to the filling load and impact of trains would have been reached long ago, and that little movement would appear in recent years. As a matter of fact, however, the track at and near the Massachusetts Avenue crossing has settled, as nearly as can be determined, the same amount as the street itself, which was filled about 1890, and opened for travel in 1891, and is now about 1.60 ft. below its original grade. The conditions on Main Street from Lafayette Square to the railroad are much the same. The street was opened for travel in 1793 and has been in continuous use. In 1873 a 36-in. brick sewer was built in the street, mostly on sand, and it is now found to be from 1.20 to 1.75 ft. lower than it was when constructed.

The other theory is that the dredging from the river and the placing of this material and other filling, together with buildings, traffic, etc., upon the tract where the original grade has been substantially raised, has produced a condition of unbalanced loading, causing a movement of the mobile materials, such as soft clay, toward the river where the pressures are less, and so a lowering of the entire overlay of harder material where this movement took place.

While most of the observations would support this theory, it seems difficult to harmonize the slight settlements noted at [12] and [13] with it.

Whatever the cause may be, if the settlement continues it will be a fruitful source of expense and trouble in the future.

FREDERIC P. STEARNS. — I wish to add, to what has been said, my own impression of the paper presented here to-night. It represents a vast amount of labor expended for the general welfare, and the Society is to be congratuated upon receiving it.

The paper asks for discussion bearing upon the question of

the height of ground water. I have been interested for many years in the ground-water levels in the Back Bay, but my information regarding these matters is not up to date.

In 1878, when the preliminary investigations for the Main Drainage Works of Boston were in progress, the question was raised as to whether a low-level system of sewers would not lower the ground-water level in the Back Bay to such an extent as to cause the decay of the piles supporting buildings, which, under the city regulations, were required to be cut off at grade 5; that is, at 5 ft. above Boston city base, which is somewhat below mean tide level. At that time pipes were driven into the ground at many places in the Back Bay and it was found that the soil water was nearly level at grade 7.7. It was also found that the soil water rose and fell, responding quickly to any rain or melting snow, and that the variation was very nearly uniform over the entire district. It is further stated that the extreme rise due to 4 in. of surface water was one foot.

These observations extended from January 17 to March 11, 1878, during a period when there was an unusually large precipitation, the total during January and February at Chestnut Hill being 12.93 ins. and at the sewer yard, Boston, 13.38 ins., with one rain in February amounting to 2.70 ins.

In 1885 these observations were repeated after the Main Drainage Works had been in operation more than a year, and the ground water was found at practically the same level as in 1878.

Still later, in January, 1894, I had occasion, in connection with the project for the proposed Charles River Basin, to again determine the ground-water levels in the Back Bay. The measurements were made at some of the pipes used for previous measurements and at many additional places. It was then found that the average height of the ground water was substantially the same as on the previous occasions, but exceptional cases were found where the ground water was much lower, in some places below grade 5, indicating that the level had been reduced locally by drainage into low-level sewers or by pumping.

The noticeable feature of the observations is the general uniformity of level and the absence of any slope toward the Charles River, which might appear to be the natural outlet for

the ground water. These facts indicate that the ground-water level is governed by leakage into the sewers, and that over the greater part of the district there is no percolation towards the Charles River Basin. They also indicate that the governing leakage is into many sewers at a comparatively high level, rather than into a few sewers at a low level. Indeed, it seems highly probable that the level in most places is governed by leakage into the house drains or into the minor sewers and not by leakage into the main sewers.

If this supposition is correct, the ground-water level of the Back Bay in the future will depend largely upon the opportunities afforded for leakage into sewers and other structures and upon the changes in conditions that are likely to take place.

What are these conditions?

The Charles River Basin, instead of fluctuating with the tide, is now maintained constantly at grade 8, which might appear to be a condition favorable for maintaining the ground water at that level, but the Charles River embankment, built for a width of 100 ft. outside of the old retaining wall back of Beacon Street, acts as a dam. Within the embankment is a marginal conduit, in which the water is maintained at a low level by means of tide gates. The old sewer outlets connected with this conduit were leaky, at the time of the completion of the basin, so that they drained the old dry rubble retaining wall just mentioned to such an extent that the water in the interstices of this wall stood several feet below the water in the basin. It was then suggested that the sewers be rebuilt and made tight or that pipes be laid from the basin to the wall to maintain the water level at the wall at grade 8, and I understand that the pipes for this purpose were laid.

The building of the subway in Boylston Street has required the temporary removal of much ground water and it is not probable that any subway when completed can be made absolutely water-tight.

A new system of sanitary sewers in the Back Bay district has been built in part. During such construction, the ground water is temporarily lowered and, as I understand the matter, these sewers are at a low level.

It was formerly a requirement, and still may be, that cellars in the Back Bay shall not be lower than grade 12, but in these days, when high buildings are being constructed and foundations can be "water-proofed," cellars are being constructed at a lower level and the drains from the buildings which are not likely to be made watertight will probably be at a lower level than those heretofore laid.

All of these changes will tend to lower the level of the ground water in the Back Bay, and such lowering will take place unless more water is supplied to the ground to offset such additional leakage.

The source of water supply at present is the rainfall and the leakage from the water pipes, with possibly a small additional amount from street and lawn sprinkling. Of the rainfall on this area, the portion which goes into the ground is decreasing, as vacant lots are being built upon and the roofs are drained directly into the sewers. This change is now taking place quite rapidly where the land was formerly occupied by the Boston & Providence Railroad. All of the changes which are taking place in this district appear to be in the direction of decreasing the amount of water which will find its way into the ground.

These considerations lead me to believe that piles to support important structures should be cut off below rather than above grade 5.

Referring now to the maximum head which must be provided in building waterproof basements in this district, it seems to me that the many outlets, which have maintained the ground-water level in the Back Bay at a nearly uniform elevation in the past, will prevent it from rising much above this level.

The results of measurements in 1878, as already stated, show that after very heavy rains the ground water rose only a foot, or to about grade 9, and it does not seem probable that the water would rise under any conditions of rainfall more than half a foot, or a foot, above this level in any part of the district well provided with house drains. The water in the sewers, when they are flooded by heavy rains, especially if such rains occur when the Charles River Basin is above its normal level, may rise as high as grade 10, or possibly grade 11, but unless there are

opportunities for the water in the sewers to communicate freely with the ground under waterproofed basements, it is not likely that the ground-water level would rise to the level of the water in the sewers.

EDWARD W. HOWE.—Mr. Hastings' experience has been about the same as mine in the Back Bay territory. We have taken a great many borings in the neighborhood of the Back Bay Fens, and the general condition shown is that there is a layer of hard gravel overlying, at various depths, soft clay which reaches to a considerable depth. It has been found that the best foundation is secured by not driving the piles through the gravel layer. Notwithstanding that the gravel appears to give a firm footing for the piles when driven, there is a continuous settlement. One example of this was very marked. At Charlesgate West there is a bridge over the Boston & Albany Railroad, built in 1882. It was built to about grade 35, with pile foundation, the piles driven to about grade -27 or -28, the borings having showed the gravel layer to be from 4 to 6 ft. in depth underlaid by clay. That bridge had not been built a great while before there were complaints that the ventilators of passenger cars were being knocked off. Observations have been taken on that bridge constantly from that time to the present and have shown constant settlement. One would suppose that it would reach a bearing eventually, but it has not yet. The diagram representing the rate of settlement shows practically a straight line, indicating a constant and uniform settlement, and the worst corner has gone down 3 ft. 8 in. in thirty years. The bridge was raised about 20 in. in 1895 and it has just been raised again. Not only the bridge, but the streets, the approaches and everything around there, have gone down.

At the bridge over the park waterway at Commonwealth Avenue we had a similar bottom and I remember distinctly the pile driving there. At about grade -10 this gravel layer of about 4 to 6 ft. in depth was found; below this to grade -75 was soft clay. The piles drove very hard through the gravel, but after penetrating through it they would go down 6 in. at a blow. We drove as long piles as we could find without

getting any greater resistance to driving than was met at the top of the gravel.

Now the mystery is, if this large area is going down, where has the material gone to in all these years? There must be something more than squeezing the water out of it, for it would seem as though in that case, as the earth became more solid, the rate of settlement would decrease, instead of which the settlement is as rapid now as it was thirty years ago. I looked at Mr. Worcester's record of borings in that vicinity. The nearest one to the bridge over the railroad was about 150 ft. away, and that shows filling down to grade 0, then mud to grade -10, then soft clay. Another boring is 250 ft. away near the new subway, and this shows loose sand and gravel to -7, coarse sand to -12, coarse sand and a little slit to -14, a little peat and fine sand to -26, sand and gravel to -29, clay to -30 and then a stiff blue clay. All around that locality about the same condition is shown. The levels on the buildings which have been built close by there showed a settlement of about 6 in. in about two years. One peculiar feature of the settlement of the Charlesgate bridge was that the abutments as they settled spread apart, the masonry tipping back against the back-filling. The only explanation of this that seems plausible is that the flats on which the abutments were built having been only recently filled, the toes of the abutments were on more compact ground than the backs and the backs settled more.

HENRY F. BRYANT. — It is a pleasure to testify to one's appreciation of the paper presented by Mr. Worcester. It is timely and sound and represents a tremendous amount of labor in collating valuable information. Our thanks are due him.

The late arrival of the JOURNAL containing the paper made formal written discussion impossible, but I am glad of this opportunity to record the thoughts which came to me as I first read it.

I concur with Mr. Worcester's intimation that the Boston Building Law, with relation to reinforced concrete, should be materially modified. While discretion in the hands of the building commissioner has so far made it possible for one to follow conservative up-to-date practice, and while I believe that

there should always be a certain amount of such discretion available, I think that the Society would do well to appoint a committee with full power to proceed along usual channels towards such a revision. I doubt the wisdom of the Society, as a whole, taking action in this matter by discussing details.

In the subsidence of the areas in Cambridge, pointed out by Mr. Worcester and Mr. Hastings, there is considerable food for thought concerning the cause. My impression is that this subsidence, like that at the Charlesgate bridges, mentioned by Mr. Howe, and that in Copley Square, mentioned by Mr. Worcester and others, is largely due to the compacting of the soft clay. I am without definite figures, but I suspect that a careful study of the situation will show that the settlements in Boston, at any rate, have been greater under the deep fills and heavy buildings than under the adjoining areas.

For instance, the Charlesgate Boston & Albany Railroad bridge abutments tip backwards against the fill, due, in Mr. Howe's opinion, to the weight of the backfilling having carried these rear piles downward, the front piles next the railroad being less affected. This condition was most noticeable at the outset, but I feel that, if there was a lateral movement of the soft clay, it would have been somewhat general and the railroad would have gone down with its immediate surroundings.

The tendency of this soft clay to settle under load must be considered in designing foundations. In my judgment, buildings on this area should have a deep, thin foundation wall, preferably supported on a single row of piles, reinforced and of considerable depth in an attempt to make them incapable of vertical deformation under superimposed loads.

The interior piers should be provided with piles in the usual way in an attempt to get a uniform pile loading throughout the structure. These piers should also be carried to the side walls by thin, reinforced cross girders of maximum depth. Such a structure would act like a ship and would float in a sound condition even though not on an even keel. Of course an attempt should be made to obtain a uniform load distribution, and care should be taken to prevent excessive loading at any point from the surrounding fill.

The Hotel Canterbury on Charlesgate West, built perhaps fifteen years ago, under my advice, but not under my supervision, had the type of foundations mentioned. I have no records of its settlement. It has been continuous and Mr. Howe mentions that it was about 6 ins. in two years.

On the opposite side of Newbury Street, the Nurses' Home is similarly designed but with a lesser depth of foundation girders and was completed this year. I expect the same settlement here and trust that it will be equally uniform.

There are no apparent settlement cracks in the Canterbury although the rear corners rest on the railroad fill.

Mr. Worcester suggests that peat at considerable depth indicates land subsidence. I accept that statement with some hesitation. In the case of fresh water peat, that is certainly not the case, as we find it to depths of forty, seventy and even one hundred feet, completely filling old glacial pot holes. I have in mind one or two instances of tidal marshes where the subsidence would of necessity be quite irregular had the bottom of the peat ever been at or near the surface. I think that the evidence is favorable for Mr. Worcester's theory, but I do not think it is by any means proven.

The appearance of silt overlying peat is new to me, but gravel on top of peat, particularly along the shore line of pot holes, is very common. Nothing but a boring will detect this.

Mr. Worcester is apparently more optimistic regarding the beneficial effect of the Charles River Basin than I am. So far I have failed to find but very few examples of its helpfulness. One was at the corner of the Parkway and Revere Street in the West End. We found ground water at grade 7 near the Parkway, but at grade 2 in the vicinity of Charles Street. The higher level was undoubtedly due to a supply from the basin or from the park, quite likely the former because of the presence of old dock walls which would readily convey the water from the basin inward. The lower grade was undoubtedly due to leakage into the interceptor. The Sewer Department and I have recently made investigations with relation to the ground water heights along Back Street, on the Back Bay. The subway pumping materially affected these observations for a time, making

it quite evident that in spite of the ground water pipes put in directly from the basin, to supply the water to the soil, the sub-way pumping took away the water faster than it would come in.

At other times it has been apparent that the Back Street sewer, which was running full, was undoubtedly draining the ground, possibly through the medium of the house connections. This may be an unusual case, but I am confident that it is not possible to maintain tight sewers and connections even with the best skill and supervision now available. I feel, to paraphrase Lincoln, that we can build part of a sewer tight all the time and all of a sewer tight part of the time, but we can't build all of a sewer tight all the time. For this reason my practice has been to adopt a cutting-off grade largely fixed by the elevation of the neighboring sewers.

In the majority of the localities in Brookline I have cut off twelve inches above the sewer level. In Boston, the presence of the interceptors has not made this possible. In one case, on Norway Street, it was found necessary to cut off at grade 1. In the Fenway section and along portions of Beacon Street the ground water elevation has been such that grade 5 to 7 has seemed to be the proper cutting-off grade. Grade 6 has probably been the average. I should advise against adopting any such grade as 8 for universal use, although I believe that Mr. Hodgdon's grade at the docks is entirely proper, i. e., grade 9.

In stating the above, I recognize the fact that ground water will protect the pile considerably above its actual level, probably due to capillarity. One pile, on Oneida Street, just examined and reported to be seventy years old, was perfectly sound with its top at grade 16. Another pile on an adjoining building, only a few feet away, was completely decayed and useless above grade 11 or 12. This pile was only about two years old. I mention these instances to illustrate the unwisdom of expecting piles to remain sound much above ground-water level.

To overcome in a measure the cost of cutting off at low grade I have made use, for some years, of concrete pile extensions. These have met with some opposition from the Building Department of the city because of the theoretical lack of lateral stability. I refer particularly to the use of headless barrels for

forms, one barrel being placed over another where necessary. As a practical matter, these barrel extensions are much safer than those piers which have their forms removed before back-filling, for the reason that they are never disturbed after being poured. Likewise, as a practical matter, the lateral stability even when no large-sized piers are used is more than ample. This is due to the surrounding earth in part but mainly to the fact that the extensions bond well to the pile head and to the superimposed concrete beams. They are also slightly inclined, particularly in a longitudinal direction. Such inclination is not enough to cause any lateral pressure on the pile heads unless they have such a lateral load as would produce that pressure in any event. After fifteen or twenty years' use of this method, I am absolutely convinced as to its stability as well as economy.

I agree with Mr. Worcester that no basement floors, unsupported, should be laid on soft peat. I do think, however, that for dwelling houses or apartment hotels, basement floors can be floated on hard fill where the amount of underlying peat is small.

I hesitate to accept Mr. Worcester's figure of grade 12 for maximum hydrostatic pressure on basements, and think that the circumstances in each case should be the sole guide. I am confident that grade 12 is altogether too high for the Back Bay. Some of the records of surface water levels in the sewers and marginal conduit show a height, as I remember it, of grade 12 or 13. Back yards of dwellings in the immediate vicinity, which were connected with these sewers, were not flooded, although their surface was as low as 10 in some cases. I have no explanation of this apparent anomaly but believe that whatever that explanation is will apply to the pressure on low basements.

Concrete is the material of all materials for foundations. It is, I believe, more suitable for that than for any other purpose, but intelligent supervision is, as Mr. Worcester states, absolutely essential. Such supervision is particularly required in cold weather such as has just passed, and, while I am not a believer in having too many rules to govern our conduct, I believe that the building law should provide something definite in this respect. I would make it compulsory that no concrete should be laid without special permission from the building commissioner,

unless the thermometer was, and had been for two hours, above 20 degrees fahr. and unless the temperature of the mix remained at or above 38 degrees fahr. for two hours after placing.

The figures on safe loading on soils appear to me as being reasonably conservative and yet not unduly so. I think that there are plenty of bowlder clays in the Boston drumlins which are capable of being loaded with safety to 8 or even 10 tons per sq. ft. I have frequently used the 8-ton figure where occasion warranted.

Mr. Worcester's figure of $3\frac{1}{2}$ and $2\frac{1}{2}$ tons on the medium and soft clays, I have been in the habit of making 3 and 2 tons, sometimes as low as $1\frac{1}{2}$ on the latter. Such tests as I have made would make me a little slow in adding that additional half ton.

I agree thoroughly with Mr. Worcester's analysis of the penetration formula for piles, called the *Engineering News* formula, and think that the use of the coefficient 3 instead of 2 is entirely justified in the majority of cases. This formula, as we all know, cannot be used in a great many cases. For instance, deep penetration into the softer sands permits a heavy loading, although the formula shows a weak pile. Against sharp resistance, with little penetration into a crust over soft bottom, which permits only a light loading, the formula shows a much greater bearing power than is safe.

If we adopt the coefficient 3, we must still further restrict the application of this formula and for that reason I am inclined to leave it as it is, expecting some liberties to be taken with it in normal cases.

The only point in which I really differ from Mr. Worcester is in the friction figure which he terms "coefficient per square foot." He, however, states that "it is not always safe to take into account the portion of the pile which is imbedded in an inferior material." I do not think that the imbedment in inferior material should ever be considered as a factor in increasing supporting power. In fact, I think that with a layer of soft material underlying a considerable depth of hard filling, the latter should be considered as negative since it is likely to sieze the pile and, in settling, to push it down. This has occurred several times in my observation.

Instead of Mr. Worcester's coefficient, I suggest the use of 1 000 lbs. per sq. ft. on that portion of the pile which is in the supporting soil. This for a pile having an average diameter of 8 ins. means about one ton per linear foot of pile in the supporting medium. From this I would deduct a similar amount for penetration in filling underlaid by any considerable depth of peat or silt.

The above figure is supposed to be 50 per cent of the actual skin friction, ignoring the bearing power of the point, which is, of course, quite small in soft material. I have used this rule for twenty years with heavily loaded piles, some of them carrying as much as fifty tons, and I have never seen a suspicion of weakness.

With Mr. Worcester's suggestion for the use of borings, I am in very close agreement. I believe that borings should be required by the Building Department wherever the bottom is not fully known or where there is a suspicion of underlying soft material. It may not be necessary to put this into the laws, but it should be thoroughly understood and expected by builders.

HENRY S. ADAMS (*by letter*). — I have read with great interest the paper by Mr. J. R. Worcester on "Boston Foundations," and his observations and conclusions are so nearly in accord with my experience that I can add but little by way of discussion.

It might be interesting to note that the material found in the excavation for the Siegel building, at the corner of Washington and Essex streets was very similar in character to that found in the Jordan Marsh building on Avon Place. The fine sand lay in a bed from 2 to 4 ft. thick immediately above the clay, at a depth of about 26 ft. below the elevation of Hayward Place. This sand would stand vertical, sometimes for several days, but ultimately would begin to flow from the bottom and cave in, acting in a manner similar to clay.

We have all had the experience in driving piles along the water front of finding extremely soft spots close to a harder material. In many cases I have found by a study of old maps that these soft places are the beds of ancient creeks, and I find it very instructive to locate, as far as possible, the old creeks

through an area in which it is proposed to drive piles. One of the most notable examples is in the Mystic River where, in building a bulkhead, the line crossed the ancient bed of the South Channel through which it was necessary to use 45 to 50 ft. piles, instead of 30-ft., which we used on both sides of the creek. I have had the same experience in South Bay.

On the subject of cut-off for piles, I think the position taken by the Building Department at the present time, of "show me," is better than adopting any hard and fast rule. In other words, they will permit any reasonable elevation for cut-off when shown the permanent elevation of the ground water.

On Pier 6 at South Boston, known as the Fish Pier, we adopted grade +9 as the cut-off, but on the south side of Northern Avenue we are using +8, although there are some indications that this elevation is considerably below the natural level of the water. Excavations made a year ago indicate that the water stood as high as grade 12 in some portions of the land.

It seems to me that the best way to determine the cut-off is first to find the elevation of the ground water, and from that the cut-off.

I have observed from time to time many examples of the subsidence of fills, especially over silt. It was found on filling the land in Cambridge upon which the Technology buildings are to be built, that there was a loss of about 25 per cent. of filling material, due to the compression of the muds and the gravel sinking into the mud. There are places in Goff's Cove where there were 30 to 40 ft. of mud and where I understand the borings show gravel at the present time.

In Charlestown about the same results were observed in filling 6 acres. I found there, that at the end of two years, the surface had settled nearly 2 ft. and is still settling to some extent. I think that Mr. Hodgdon can give us some very interesting data in relation to the settlement of the South Boston flats.

It has been my experience in filled areas that after a time the material has settled away from under the piers, leaving the entire load carried by the piles; and for that reason, in putting

in the foundations for the buildings on the Fish Pier I have made no allowance for any load to be carried by the fill. The entire load is on the piles, and in figuring the piles I have assumed that the material of the fill and the underlying mud or silt have no sustaining power, but will, on the contrary, tend to pull the piles down as the material settles; therefore I rely entirely upon the clay for supporting the buildings.

I have found in driving piles along the water front that a 12-ft. penetration into the average clay is safe for about 10 tons, and 20-ft. into similar clay is safe for about 25 tons. Such clay is commonly marked in borings "blue clay," or "stiff blue clay," and will give a uniform penetration for a pile of about 4 in. to a blow under a 2 800-lb. hammer falling 10 ft. The usual method that I employ for testing a pile is to let the pile set in the ground for at least twenty-four hours and then resume driving, taking the penetration for the first four blows, and using the *Engineering News* formula to obtain the sustaining power of the pile.

I think it is very important to make the tests after the pile has set, and not immediately after driving. It takes a period of time for the clay surrounding the pile to grip the pile. Such tests usually show that the pile will sustain, after a twenty-four hour set, three to four times the load that it will when first driven. As nearly as I can estimate it, the clay, after having thoroughly set, has a grip per square foot upon the pile of about one third of the load that we would ordinarily place upon the clay for foundation. For example, if the clay is good for 3 tons per sq. ft. for foundation, it is good for about 1 ton per sq. ft. in grip upon the pile.

As moist clay acts as a fluid, I have often figured that it is not safe to put upon clay a much greater load than the weight of the material over the clay, because clay has a tendency to flow upward as well as sideways. There is danger in driving piles in clay of putting the piles too close together. The old rule that was taught me when I first went to work, that piles should not be driven into clay closer than 3 ft. on centers, I think is a safe one. If they are driven closer than that in clumps, the material between the piles is so compressed that

it loses its grip, and does not hold the interior piles to the extent that it should.

The modification of the *Engineering News* formula for the supporting power of piles, as suggested by Mr. Worcester, seems to be a good one for the material around Boston.

In practice, I do not think it is safe to figure a load of over 10 tons on the ordinary spruce pile, but on oak piles I have allowed loads as high as 30 tons. Where the water is so deep that a pile would not be safe for such a load if used as a column, I figure it as a column only, and not a pile.

It might be interesting to read from the records of the Proprietors of Long Wharf the story of one of the earliest borings:

“LONG WHARF WELL.”

“The depth of the well is 35 ft. From the bottom of the well to the spring is 62 ft., making 97 ft. from the top of the well to the spring. The inside curb which forms the well is 4 ft. in diameter on the inside and perfectly tight at the bottom. In digging the well from the platform which now covers it, we dug through the wharf about 16 ft., thence through the flats 14 ft. We then came to a marsh of about 6 ins. in thickness under which was pure clay. We dug into this clay about $4\frac{1}{2}$ ft. and then put down the inside curb. In boring for the fresh water we proceeded as follows:

“We first made a hole in the bottom of the curb $10\frac{1}{2}$ ins. in diameter; then bored into the clay 8 ft. with an auger 10 ins. in diameter. We then took a log 15 ft. long and 10 ins. in diameter with a hole through it of 5 ins. diameter which we put into the hole at the bottom of the curb and drove it with a large iron weight 13 ft., leaving 2 ft. above the bottom of the curb; then with an auger 5 ins. in diameter bored through the hollow log 35 ft. from the bottom of the well through pure clay. We then came to sand from which we had a small quantity of fresh water. Through this sand we bored about 23 ft. and then came to pure clay. We bored through this clay about 7 ft. and came to a hard pan of slate and on taking up the auger found the water to rise fast. We then put a tube $4\frac{1}{2}$ ins. in diameter into the hole we had bored, which hollow tube extends from the bottom of the well to

the hard pan of slate. We then fixed a drill on the shank of the auger and let it down through the hollow tube and drilled into the hard pan bottom about 3 ft. We found we had struck a spring affording an abundant supply of water. The well at Long Wharf was begun Monday, June 12, 1797. Began to bore for a spring Monday, Sept. 4; got to the spring Wednesday, Sept. 6, at 11 o'clock; put in the pump Saturday, Sept. 9, at 12 o'clock. Began to receive pay for water Monday, Sept. 11, being just three months from the time it was begun."

This well, which was situated about 150 ft. east of Atlantic Avenue, was cut off by the East Boston Tunnel.

RALPH E. RICE (*by letter*). — Mr. Worcester describes, in the division of his paper entitled "Pressure on Soil," what he considers the best way to make a test of the bearing power of soil. The Boston Elevated Railway Company made three such tests, preliminary to the construction of the Cambridge Main Street Subway, in that section of Cambridge that is and for years has been settling, using the method suggested by Mr. Worcester.

Mr. L. M. Hastings, city engineer of Cambridge, has fully described the geological formations between the Charles River and Central Square. In the forty years between 1869 and 1909 the surface at Lafayette Square had settled 2 ft., while at Central Square, 1 300 ft. west, there had been almost no settlement. At Brookline Street between these two points and about 500 ft. from Lafayette Square a wash boring shows 96 ft. of soft clay before hard material is reached. This condition warranted a careful study of the bearing power of the soil in the subway location.

The test made at Lafayette Square was typical of the three tests and will be briefly described. The object was to determine the bearing power of the soil at the elevation of the bottom of the invert of the proposed subway. A pit 7.5 ft. wide, 9 ft. long and 24 ft. deep was excavated and sheeted and near the center of the bottom a hole 3.5 ft. by 3.5 ft. by 2.5 ft. was carefully dug into the undisturbed clay and a box of 2-in. plank 3 ft. by 3 ft. by 3 ft. outside dimensions, without top or bottom, inserted. Spikes were driven into the inside of the box so as to protrude about 2 ins., six or eight being driven into each side to act as a bond

between the box and the concrete which was placed in it. The concrete and the box would then act as a unit and form a foundation 3 ft. square resting on the undisturbed soil.

On the bottom of the pit, which was leveled off, were placed timbers and a flooring, built as tightly as possible and firmly braced from above to prevent any upward movement which might be caused by the pressure. Several $\frac{1}{2}$ -in. observation holes were bored in the flooring to permit detection of any movement of the soil underneath. The ground water was kept pumped out by a steam pump.

Four upright timbers were placed on the top of the concrete foundation to support a box, 7 ft. square, made of 2-in. plank which contained the load of earth, the material excavated from the pit being used. This superstructure was centered over the center of the foundation. Lateral spreading of the box was prevented by stretching two sets of No. 10 gage wire both ways across the box.

A gage box of convenient size was made and the amount of earth sufficient to fill it was weighed on platform scales, enough earth being placed in the box to make, with the wooden structure, a load of about 2 000 lbs. per sq. ft. on the soil. Elevations were read on a spike in the top of a 4-in. by 4-in. post attached to the floor and extending perpendicularly in the center of the box.

The load was increased daily about 1 000 lbs. per sq. ft., observations being made about fifteen minutes after each increase of load and every night and morning. When the load had reached 6 tons per sq. ft. the box was about 11 ft. above the surface and leaned from the perpendicular about 5 ins. in 15 ft., and it was considered unsafe to further increase the load. This load of 6 tons per sq. ft. was allowed to remain for five days before removal.

Frequent examinations were made to ascertain if the soil was rising in the bottom of the pit, but no such movement was observed. While making such an observation, after the load of 6 tons per sq. ft. had been reached, a loud cracking was heard and, remembering the nearly 18 tons of earth overhead, a hurried exit was made from the pit. Nothing happened, but this cracking noise led to an examination of the superstructure and it was

discovered that the 6-in. by 6-in. floor timbers had crushed about $\frac{1}{4}$ to $\frac{3}{8}$ in. directly over the upright posts, so that this and probably a small additional amount should be subtracted from the total settlement.

The soil at the points of testing was as follows: Test 1, at Massachusetts Avenue and Pearl Street, fine sand with enough clay to hold it together. Test 2, as described above, and Test 3, at Main Street nearly opposite Cherry Street, soft blue clay.

A settlement of $\frac{1}{2}$ in. was obtained with a load per sq. ft. in Test 1 of about 1 100 lbs., in Test 2 of 3 000 lbs., and in Test 3 of 7 000 lbs. A settlement of 1 in. was obtained with a load per sq. ft. in Test 1 of 10 300 lbs., in Test 2 of 6 000 lbs., and in Test 3 of 10 000 lbs. A settlement of 2 ins. was obtained with a load per sq. ft. in Test 1 of 17 000 lbs., in Test 2 of 11 000 lbs., and in Test 3 of 14 000 lbs.

These tests were made in September, October and November of 1906, under the direction of the late George A. Kimball, then chief engineer of Elevated and Subway Construction, and Mr. F. B. Edwards, division engineer. The writer had field charge of these tests and the previously made wash borings.

CHAS. T. MAIN (*by letter*). — We are indebted to Mr. Worcester for his very able and important paper.

I desire to say a few words regarding the conclusions which he has reached and recommendations made, and to add something concerning the work on the foundations for the new buildings of the Massachusetts Institute of Technology, which are now under construction on the new site in Cambridge.

Too much stress cannot be placed on the necessity of obtaining as full knowledge as possible of the conditions of soil or ledge underlying a proposed structure. I decided some time ago that I would not design and build any structure of importance without obtaining sufficient knowledge by borings, or preferably by test pits, if possible, to be sure that the foundations are properly designed to prevent settlement or failure, and that no money is spent in making them unnecessarily costly.

There have come to my notice many instances where this has not been done and where great expense has been incurred in trying to make things right afterwards, and many instances

where insufficient or lack of explorations have been the cause of too low estimates of cost.

I believe that the cost of such explorations is always justified and has often saved many times the amount later on in construction.

Explorations in Boston should include borings carried to bedrock if possible and the taking of dry samples of the soil every few feet in depth. The samples should be examined as soon as taken, as moisture evaporates and the character of samples changes rapidly.

(a) A record should be made of water levels.

(b) Test piles should be driven, keeping careful records.

(c) Piles should be tested by loading until marked settlement takes place, and careful readings made before and after each increment of load, loads being allowed to rest at least twenty-four hours after each increment, if possible.

(d) All test piles should be pulled, whether load tested or not, to determine their condition and suitability for the work.

There can be no exception to the importance of supporting all parts of the structure on a stratum of soil below the silt and peat.

There can be no doubt of the necessity of determining the maximum and minimum levels of the ground water.

The most of my work has had to do with buildings used for manufacturing purposes, which are subject to more or less vibration, and very few have been in the limits of the city of Boston. Because of the effect of vibration and the observance of what happened in a weaving mill in the earlier part of my experience, I have been very conservative regarding the loads on soils, and many years ago decided on the following:

Soft clay — One ton per sq. ft.

Compact sand and gravel — One to two tons per sq. ft.

Hard pan — Two to three tons and sometimes, under favorable conditions, four tons per sq. ft.

Except on soft clay I have increased these loads somewhat in later years, with more accurate knowledge of the conditions of the soil, and under favorable conditions with reference to the occupancy of the buildings.

In most of my work the loads on the footings are naturally rather low, and I have no special difficulty in keeping them down.

SUPPORTING POWER OF PILES.

The results obtained so far on the new site of the Institute of Technology show that piles which have been properly driven, i. e., not broomed or broken, have a bearing capacity under the test loads slightly in excess of that indicated by the *Engineering News* formula, but those which have brought up hard and have been crippled have shown a very much less capacity under test load than was indicated by the formula.

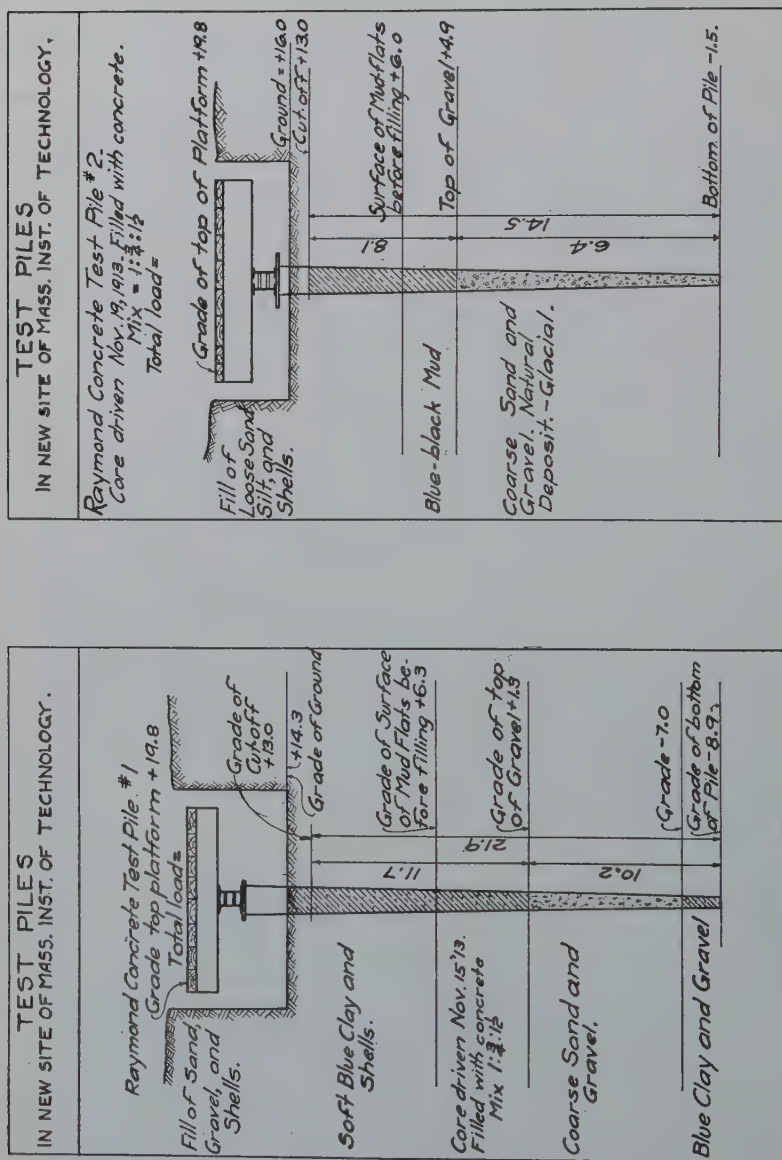
PILING AT MASSACHUSETTS INSTITUTE OF TECHNOLOGY SITE IN CAMBRIDGE.

Tests and observation show plainly that spruce piles, without iron points, should be used cautiously in the Boston Basin, owing to the fact that the blue clay is often overlaid with a hard crust of gravel or sand. Reports of old piles which have been pulled in various parts of the city and found badly broomed and broken, as well as the numerous tests made at site of the Institute of Technology, show plainly that spruce is not suitable for anything but easy driving into loose sand or soft clay.

Piles broomed and broken near their points, but which are deeply embedded, may have a good bearing power from friction alone, but broken and broomed piles having no frictional support to depend upon will settle badly and may fail under ordinary loads.

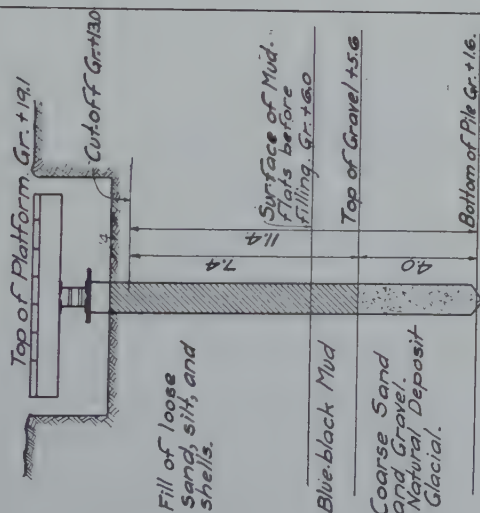
The large number of piles tested show plainly that while the spruce piles failed to penetrate the hard crust, brooming and generally breaking, oak piles not having iron points will penetrate the hard ground and come practically to a standstill without material injury. Any wood pile which is to depend largely upon point bearing for its value should be oak or southern pine.

An interesting point is brought out by a study of the driving and testing records of some of the piles. These piles generally pass through a fairly hard fill of blue-black silty mud and shells before reaching the harder sand stratum in which they get most of their support. This fill gives considerable resistance to



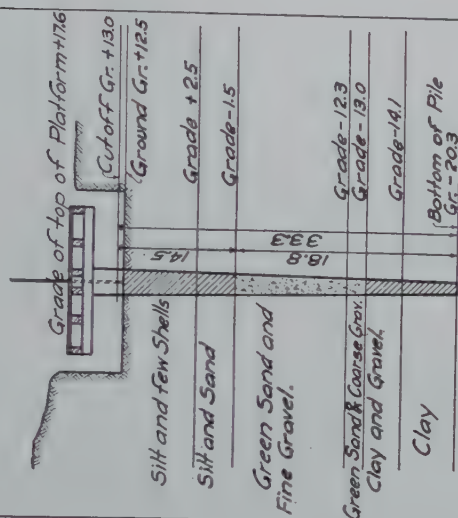
TEST PILES
IN NEW SITE OF MASS. INST. OF TECHNOLOGY.

Simplex Concrete Pile #4
Pile driven Nov. 24, 1913
Concrete 1:2½:5

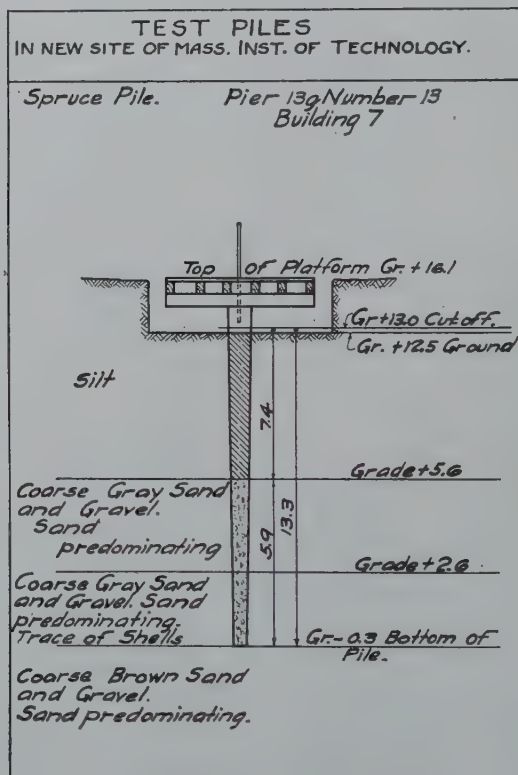


TEST PILES
IN NEW SITE OF MASS. INST. OF TECHNOLOGY.

Spruce Pile. Pier 2a, Number 2a
Building #8



driving, and soon after the pile reaches the sand, it would generally appear, by the small penetrations under the hammer, that a theoretically satisfactory bearing power has been reached. This is not practically acceptable, however, as the fill is unreliable and subject to large future settlement owing to decomposi-



tion, etc., and should not be depended upon for permanent support, even if it appears to give temporary support, therefore the piles are driven into the hard sand stratum to a depth that will give a satisfactory support to them from that material alone. This is also necessary, in order to give stiffness to the structures against vibrations, especially where the fill is soft.

As noted before, most of the test piles, under actual loading test, could be allowed a slightly higher value than the *Engineering News* formula gave them, provided a very small initial settlement is allowed as not detrimental. If a settlement of $\frac{1}{4}$ in. is assumed as maximum, they have a factor of safety of 2 to 3, the piles having a deeper embedment as a rule showing the larger safety factor.

As the hard sand or gravel crust in the Boston Basin is often found over a deep soft underlying clay, it will reduce the possibility of settlement in those structures, which are to be supported upon the crust, if the piling or foundations are well spread so as to avoid concentrations of loads.

If the bearing stratum were not so far down as to make excavation in the fill, silt and water so expensive, the best thing to do would be to rest the concrete foundation directly on the hard stratum. This being out of the question, the next best thing seems to be to spread the weight over as much area as possible by driving a large number of wooden piles. Concentration of loads in a much smaller number of places spaced much farther apart would seem to be the least desirable method with a stratum of hard material of small thickness over a soft clay bed.

Professor William O. Crosby has made a report on the geological condition at the Massachusetts Institute Technology site, which is included as a part of the discussion.

RECORDS OF OTHER BORINGS AND TESTS.

SOUTH BOSTON. South Cove District — Old Colony Ave., Earl St., Damrell St. Two sets of borings.

Black soft peat found in layer varying from 2 to 7 ft. in thickness, having no marked inclination, top at about grade 8.5 and bottom at about an average grade of 3.6. Under this peat is found water-bearing sand, and this lies on hard yellow clay generally, with hard blue clay under the yellow. Then is found a soft blue clay, of unknown thickness, high parts at about -9.5 and dropping to -17 in a westerly direction.

It cannot be said that these borings show any marked subsidence of the sub-soil in recent times, as the peat is probably near its original location.

Identity.	Character.	Total Length in Ground. (Feet.)	Length in Sand or Gravel. (Feet.)	Tip Diameter in Inches.	Weight of Hammer in Pounds.	Fall of Hammer in Feet.	Penetration, Last Blow, in Inches.	Test Load. (Lbs.)	Settlement. (Inches.)
2a 2a 8	Spruce	32.8	16.6	5½	2 150	10	2	8 990 13 760 20 030 28 210 34 200 40 040 45 898 51 000 58 070 62 360	0 8 8 1 5 10 15 20 25 30 35 40 45 50 55 60
13g 13 7	Spruce	12.8	5.8	6	2 300	10	2½	6 570 11 860 21 300 26 480 32 423 37 560 42 960	0 1 3 3 5 8 11 15 18 22 26
1	Raymond concrete Near No. 14 wood pile given by Mr. Worcester,	23.2	10.2 (Pile	8 did	No. 1 Vulcan. Weight of moving parts, 5 000 not fail)	2.25	5 blows per inch	41 050 46 070 61 810 81 840 86 710 90 890 100 330 125 340 144 770 171 750 182 120	0 1 1 1 5 8 12 15 18 22 26 30 34 38 42 46 50 54 58 62 66 70 74 78 82
2	Raymond concrete	17.5	6.4 (Pile	8 did	5 000 No. 1 Vulcan not fail)	2.25	4 blows per inch	29 650 44 420 59 360 110 630 122 280 126 700 131 610 158 104 169 980 175 870	0 1 1 1 3 6 9 12 15 18 21 24 27 30 33 36 39 42 45 48 51 54 57 60 63 66 69 72 75 78 81 84 87 90 93 96 99 102 105 108 111 114 117 120 123 126 129 132 135 138 141 144 147 150 153 156 159 162 165 168 171 174 177 180 183 186 189 192 195 198 201 204 207 210 213 216 219 222 225 228 231 234 237 240 243 246 249 252 255 258 261 264 267 270 273 276 279 282 285 288 291 294 297 300 303 306 309 312 315 318 321 324 327 330 333 336 339 342 345 348 351 354 357 360 363 366 369 372 375 378 381 384 387 390 393 396 399 402 405 408 411 414 417 420 423 426 429 432 435 438 441 444 447 450 453 456 459 462 465 468 471 474 477 480 483 486 489 492 495 498 501 504 507 510 513 516 519 522 525 528 531 534 537 540 543 546 549 552 555 558 561 564 567 570 573 576 579 582 585 588 591 594 597 600 603 606 609 612 615 618 621 624 627 630 633 636 639 642 645 648 651 654 657 660 663 666 669 672 675 678 681 684 687 690 693 696 699 702 705 708 711 714 717 720 723 726 729 732 735 738 741 744 747 750 753 756 759 762 765 768 771 774 777 780 783 786 789 792 795 798 801 804 807 810 813 816 819 822 825 828 831 834 837 840 843 846 849 852 855 858 861 864 867 870 873 876 879 882 885 888 891 894 897 900 903 906 909 912 915 918 921 924 927 930 933 936 939 942 945 948 951 954 957 960 963 966 969 972 975 978 981 984 987 990 993 996 999 1002 1005 1008 1011 1014 1017 1020 1023 1026 1029 1032 1035 1038 1041 1044 1047 1050 1053 1056 1059 1062 1065 1068 1071 1074 1077 1080 1083 1086 1089 1092 1095 1098 1101 1104 1107 1110 1113 1116 1119 1122 1125 1128 1131 1134 1137 1140 1143 1146 1149 1152 1155 1158 1161 1164 1167 1170 1173 1176 1179 1182 1185 1188 1191 1194 1197 1200 1203 1206 1209 1212 1215 1218 1221 1224 1227 1230 1233 1236 1239 1242 1245 1248 1251 1254 1257 1260 1263 1266 1269 1272 1275 1278 1281 1284 1287 1290 1293 1296 1299 1302 1305 1308 1311 1314 1317 1320 1323 1326 1329 1332 1335 1338 1341 1344 1347 1350 1353 1356 1359 1362 1365 1368 1371 1374 1377 1380 1383 1386 1389 1392 1395 1398 1401 1404 1407 1410 1413 1416 1419 1422 1425 1428 1431 1434 1437 1440 1443 1446 1449 1452 1455 1458 1461 1464 1467 1470 1473 1476 1479 1482 1485 1488 1491 1494 1497 1500 1503 1506 1509 1512 1515 1518 1521 1524 1527 1530 1533 1536 1539 1542 1545 1548 1551 1554 1557 1560 1563 1566 1569 1572 1575 1578 1581 1584 1587 1590 1593 1596 1599 1602 1605 1608 1611 1614 1617 1620 1623 1626 1629 1632 1635 1638 1641 1644 1647 1650 1653 1656 1659 1662 1665 1668 1671 1674 1677 1680 1683 1686 1689 1692 1695 1698 1

Ground water level not recorded. Concrete piles used in two buildings.

CHARLESTOWN. Rutherford Ave. and Thorndike St.

Borings show the usual fill, mud, peat and sand mixed, loose sand and hard pan or hard packed gravel and rocks. Ground water is at about grade 7.

This location is about on the original shore line of the district, as the peat thins out to practically nothing at the northeasterly part of the lot.

The general inclination of the gravel, sand and peat is downward to the south.

Buildings in this vicinity are generally low and rest on the fill overlaying the mud and peat, consequently all heavily loaded buildings show marked settlements and are vibrated by every heavy team passing on Rutherford Ave.

The gravel or hard pan found under this site appeared to be very thick and was not wholly penetrated by our borings.

REPORT ON THE NEW SITE OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

By W. O. Crosby.

ORIGINAL TOPOGRAPHIC RELATIONS.

The new site, like the old site, is made land, reclaimed by human agency from the estuary of the Charles. The charts, alike of 1859 and 1887, show the new site as wholly included in the expanse of mud flats on the north or Cambridge side of the estuary, barely touched by bordering salt marsh at one point on the north, and by Whittemore Point, a low ridge or spit of glacial gravel, on the west, near the end of Harvard Bridge. The salt marsh tends, in general, to encroach upon the mud flat, and thus, eventually, a layer of peat is spread over the silt. Alternations of silt and peat in different parts of the Back Bay district and of Boston Harbor, extending to depths of 15 to 30 ft., testify to repeated oscillations of level accompanying a general slow subsidence of the coast.

The fact that no peat was found in any of the borings on the new site, a fact of considerable practical importance, shows con-

clusively that this has been a water area, at high tide (mud flat) if not at low tide (open channel), during all the latter part, at least, of post-glacial time. The older maps and charts represent several salt-water creeks or tidal channels as issuing from the marsh and uniting in the northern part of the new site to form a main channel, which crossed the line of the Esplanade near the southeast angle of the site on its way to join the main channel of the estuary. The head branches of these creeks and the salt marsh through which they meandered were effaced at an early date in the development of this part of Cambridge; but the new site of the Institute remained essentially unchanged until the building, in the early nineties, of the retaining wall of the Esplanade and the filling of the area thus enclosed with silt and sand pumped from the bed of the river.

SOURCES OF INFORMATION.

To determine the character, thickness and succession of the substrata, including both the bedrock and the over-burden of unconsolidated materials, twenty-two deep borings have been made on the new site. These were systematically distributed, with a view to covering somewhat uniformly the entire tract, as shown on the boring plan and sections. Borings 2 and 20 were subsequently confirmed by test pits to depths of 19 and 26 ft. respectively. Three borings, also, have been made to the northward, at varying distances, beyond the limits of the new site, with a view to determining the probable causes of noteworthy settlements of various structures on the lowlands of Cambridgeport. A still broader and more comprehensive knowledge of the geological conditions on the new site has been made possible by a study of the very numerous borings that have been made in the surrounding territory in connection with the construction of the Harvard and Cambridge bridges, the Charles River Dam (and the marginal conduits of the Charles River Basin), and the Boston and Cambridge subways, and for many lesser undertakings and private interests, including a considerable number of deep wells. Back of all these special sources of information come the general conclusions in regard to

the geologic structure derived from a study of the ledges and drift deposits of a large part of the Boston Basin.

THE BEDROCK.

Of the twenty-two borings on the new site, ten reached the bedrock at depths of 120 to 135 ft., and penetrated it for varying distances, the maximum penetration being about 61 ft., in boring 9, which reached the extreme depth, for this series, of 192 ft.

The bedrock is, in all the borings which have reached it, a light gray, banded or thin bedded slate, resembling much more closely the slate ledges of Brighton and Newton than of Somerville. The cores show prevalent high dips (30 degrees to nearly or quite vertical); and, what is more important, they also show the slate to be extensively and deeply decomposed. In fact, the slate is, in large part, rotted to a whitish and more or less plastic clay; and close observation is necessary to determine the line between the drift and the bedrock. Under these conditions, naturally, only a very small percentage of core was saved, mainly in small pieces; and these must be supposed to represent only the more solid parts of the ledge. The great depth to which this decay of the slate has extended is rather surprising; and even in the bottom of boring 9, 61 ft. below the surface of the ledge, the slate is far from sound.

This deep decay of the bedrock is unquestionably local, and it is best explained as dating from preglacial times and as having survived glacial erosion in consequence of its occurrence in a sheltered position relatively to the surrounding bedrock areas, a deep, narrow valley transverse to the glacial movement being the most obvious suggestion. The borings afford proof of the existence of such a valley, trending southwesterly from the slate ledges of Somerville and Cambridge to join the still deeper buried valley of the preglacial Charles, the course of which is southeasterly from Watertown across the Back Bay and South End districts of Boston to Dorchester Bay. It follows, then, that beneath the new site of the Institute the surface of the slate bedrock is quite certainly deeper and less sound than beneath the territory to the north and south — Cambridge and Boston.

Although it would not, probably, be impossible to sink concrete piles to the bedrock, the expense of doing so would be prohibitory; and it is, fortunately, quite unnecessary to resort to this costly expedient to secure a satisfactory foundation for any structure which it is proposed to erect on the new site. We need not, therefore, regret that the surface of the bedrock is not so sound and solid as would be desirable if the stability of the projected structures depended upon it. Its depth completely eliminates the bedrock as a factor in the problem of providing a stable and enduring material foundation for the new Institute.

THE OVER-BURDEN.

The unconsolidated materials overlying the bedrock, include, in succession; (1) the boulder clay or ground moraine of the great ice sheet; (2) the blue clay, deposited in standing water (glacial lake) along the receding margin of the ice sheet; (3) the glacial gravel deposited, delta-fashion, by streams tributary to the glacial lake; (4) the silt deposited by the river and tidal currents during post-glacial time; (5) the peat formed on the marshes simultaneously with the silt and frequently interstratified with the latter; (6) the artificial filling, bringing the surface to grade and converting mud flats to dry land. The relative thickness and general structural relations of these several formations are clearly exhibited, for the new site, by the boring sections.

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SUMMARY OF FOUNDATION CONDITIONS.

The bedrock (chiefly slate) is too deep to be seriously considered. Furthermore, it is deeply rotted, and if it were accessible it would probably require extensive excavation.

The boulder clay, comparable with the bedrock in stability, is also at an impracticable depth.

The great bed of blue clay overlying the boulder clay is undoubtedly more firm and stable than might be inferred from the moist samples furnished by the drill. This formation, reinforced by piles, has been the main reliance for deep foundations,

or the foundations of important structures, throughout a large part of the lowland areas of the Metropolitan District.

The glacial gravel (and sand) covers the blue clay over almost the entire area of the new site, and it is thickest and nearest the surface over that part of the site on which, chiefly, buildings are to be erected in the near future. The value of this formation for foundation purposes is shown not only by the resistance which it offers to piles, but also by its efficiency in distributing the load which must ultimately be borne by the blue clay. It is, in this respect, somewhat comparable to a bed of concrete spread over the surface of the blue clay. It should be, for the new site, the main reliance for foundations. No attempt should be made to excavate it, nor, in general, to drive piles through it; but the structures should, instead, rest upon it, either directly or through the medium of piles.

The silt is on no part of the new site so deep as to make it a necessary factor of the foundations, except in the sense that it may be excavated to permit placing the foundations of structures directly upon the glacial gravel. In other words, it affects the problem of a safe and satisfactory foundation only in a negative way.

The peat, so generally interstratified with the silt in surrounding districts, is, fortunately, conspicuous by its absence on the new site and is to be taken into account only in helping to explain the subsidence of structures in the adjacent territory, which is very generally underlain by peat.

COMPARISON OF THE NEW SITE WITH THE OLD SITE.

This comparison is decidedly reassuring as to the solidity and permanent stability of the new site, for the advantage or superiority is with the new site in every particular; and yet the old site, during a half century of occupation, has proved very satisfactory, except, perhaps, in the transmission to the buildings of the vibrations due to street traffic. The buildings have not settled appreciably, and certainly they have not settled differentially to such a degree as to involve cracking of the walls or other noteworthy injury. So far as known, the same is true of surrounding structures, some of which are of a very massive

character, except for a slight differential settling of the Public Library and of the New Old South Church, the tower of the latter structure having settled so that it has a considerable lean from the vertical.

To particularize geologically; according to the best information obtainable from deep wells, the depth to the slate bedrock is greater, probably 30 or 40 ft. greater, for the old than for the new site; the depth of the bowlder clay and the thickness of the blue clay are correspondingly greater for the old site; the glacial gravel (and sand) covering the blue clay on the new site is wholly wanting on the old site; the silt is thickest on the old site; and in the lower part of the silt on the old site are one or more thick beds of peat, a specially undesirable feature which is wholly wanting on the new site.

The great or decisive advantages of the new site are the presence of the glacial gravel and the absence of the peat; and in view of the fact that the old site has proved reasonably satisfactory without these advantages, we are certainly justified in regarding the new site as virtually above suspicion, the more especially since, as will be shown in the next section, the settlements which have been noted in the vicinity of the new site are clearly due to shallow foundations, the presence of peat, or to other causes which are and will be non-existent on the new site.

SETTLEMENT OF BUILDINGS AND OTHER STRUCTURES IN THE VICINITY OF THE NEW SITE.

The appended list * of fairly well-determined instances of settlement in the vicinity of the new site seems to show that settlement is a more or less general fact, and a fact demanding careful consideration and explanation. The principal causes of settlement have been noted, and it remains to show their applicability to the concrete examples. A large majority of the observed settlements are referable to four linear series, as follows:

Charles River Parkway, south of the new site.

North Metropolitan Sewer, north of the new site.

* This list is omitted, as the settlement of this region has been fully indicated elsewhere in this discussion.— Editor.

Massachusetts Ave., west of the site.

Main St., east of the new site.

Since the series completely surround the new site, the conclusion appears unavoidable that it, too, or at least structures placed upon it, must be subject to settlement; and this, doubtless, would prove to be the case were as little care exercised in the planting of structures on the new site as on the circumjacent territory.

It remains now to consider briefly the settlements of the several series with a view to determining the probable causes, the extent to which, if at all, these causes are inherent, in the new site and the appropriate remedies.

Charles River Parkway (Esplanade). — The observations of this series were made, not on the seawall, but along the inner margin of the Parkway. The seawall rests, not upon piles, as one would naturally expect, but directly upon the mud and silt of the original bottom of the estuary; while the parkway itself rests upon the made land behind the wall, the filling of silt upon silt, certainly not an ideal basis, even for a roadway. Under these conditions it is not surprising that both parkway and wall should have settled, but rather that they should have settled so little.

The parkway was finished to grade 21 in 1897; and no subsequent determinations of levels were made until 1908, when the results shown in the table were obtained, the total settlements ranging from .07 to .70 ft., equivalent to .0064 to .064 ft. per year. A uniform annual rate of settlement at each point is, however, extremely improbable. It is practically certain that the rate was relatively rapid at first, when the filling was but slightly compacted or settled, becoming gradually slower and finally almost stationary. The annual rates at the present time must be distinctly less than the mean annual rates given in the table, except perhaps at the corner of Ames St. and the south-east corner of the new site, where a second determination in 1912 showed a substantial continuance of the mean rate from 1897 to 1908. This is also the point of maximum movement, the total settlement being nearly double the next highest total

and much more than double the mean total. Evidently, exceptional conditions must exist here, and what these exceptional conditions probably are becomes apparent when we note that this point is on the most probable course of the tidal channel or creek which we have seen must have flowed southeasterly from the northern central part of the new site. Clearly, both the original silt and the filling must have exceptional thickness here; and hence it is not surprising that settlement of the surface should still be active, but that it will so continue is extremely improbable, the probability being, rather, that it has already begun to slow down and that it will, virtually, cease in the near future.

That the observed settlements of the parkway are due much more to the yielding of the filling than of the original deposit on which it rests is indicated by the statement of the city engineer of Cambridge to the effect that the retaining wall of the parkway (seawall), which we have noted as built upon the original deposit, but which, of course, cannot rest upon the filling introduced subsequent to its construction, has maintained almost its original level, having settled in all possibly one inch. He excepts, however, the point at the southeast corner of the new site, opposite the end of Ames St., where the wall crosses the old tidal channel. An apparent settlement of 6 ins. has been noted here, or about one half as much as for the corresponding point on the parkway. It appears, then, that the wall, with a decidedly greater weight per square foot than the material beneath the parkway, has proved the more stable, simply because it consists of unyielding granite resting upon original and relatively compacted deposits, while the material beneath the roadway is filling which has been, and is yet to some degree, uncompacted.

The wall, of course, and not the parkway, best exemplifies the conditions that will obtain on the new site, for the filling, it may be assumed, will not be a factor in the foundations of the proposed buildings, the foundations being carried either directly by excavation or by piles through both the fill and the silt to the glacial gravel. When we consider that the foundations will thus rest upon the glacial gravel, while the retaining wall rests upon silt and blue clay, with little or no gravel intervening,

we cannot doubt that the former will prove far more solid and stable than the latter, although the behavior of the latter (the wall) appeals to the engineer as, on the whole, highly satisfactory.

North Metropolitan Sewer. — This heavy masonry structure, dating from 1892, was built in the silt, with its base at or near the low tide level. The minimum settlements of the sewer in Cambridgeport are in the vicinity of Albany and Franklin streets, where it must rest upon or near the glacial gravel, and east of Main St., where the boulder clay must approach the surface. In the vicinity of Massachusetts Ave., and between the avenue and Main St., the sewer crosses territory known to be underlain by peat; and it is legitimate inference from the official reports on the construction of this sewer that there is more or less peat below this section of the sewer. Peat, therefore, may be regarded as a probable cause of the settlement of the sewer. The reports state, also, that the sewer rests, in part, upon fine sand (probably glacial); and Mr. Charles R. Gow suggests that through the action of the pump used to drain the excavation during the construction of the sewer some of this fine sand was drawn through the open joints of the underdrain, thus undermining the sewer and permitting its subsequent settlement. This appears very probable and may be set down as a second cause of the observed settlements. A third cause is found in the fact that the maximum settlements, near Massachusetts Ave. and near the junction of Albany and Portland streets, coincide with the positions of the creek channels coursing through the ancient salt marsh. It appears, then, that even the extreme settlement of 2.3 ft. (0.1127 annually) directly north of the new site, on Albany St., may be fully accounted for without impeaching the foundation conditions of the new site.

Massachusetts Avenue. — It is needless to go into details here. The examples of settlement speak for themselves in the tabulated list. With rare exceptions, piles are wanting and the buildings rest, with shallow foundations, upon fill, silt, quicksand or peat; or, as in the case of the Metropolitan Storage Warehouse, upon the exceptionally deep filling of ancient creek channels. Riverbank Court, Seymour Apartments and the Armory rest upon the glacial gravel, and in their freedom

from settlement we have a plain indication of what may be expected on the new site.

Main Street. — This section, also, may be disposed of very summarily. The settlements are either very slight or the structures rest without adequate foundations on yielding materials, — fill, silt, peat or quicksand. All the observed settlements of any importance might have been predicted. In several instances the settlements are too slight to require explanation.

Miscellaneous Series. — The miscellaneous group of settlements east of Main St. are too slight to require explanation, with one exception, and in this case the conditions are not known.

SETTLEMENT TESTS ON THE NEW SITE.*

Respectfully submitted,

(Signed) W. O. CROSBY.

FRANK H. CARTER (*by letter*). — The Society is to be congratulated upon having a member who is willing to devote so much of his time to the preparation of so valuable a paper.

As a matter of record, the writer desires to present, as a part of the discussion, additional data concerning the subsidence of part of Cambridge. That a large part of Cambridge has been undergoing a progressive settlement has been definitely known since 1897, when the writer was engaged in making an investigation of facts regarding the back flooding of certain sewers in the low area of Cambridge. Previous to that time, there had been trouble with some of the benches near Lafayette Square, but the difficulty had been thought to be local only. Under the direction of Mr. L. M. Hastings, city engineer of Cambridge, the writer ran levels through practically all the streets in the sunken district. Elevations were taken on bench marks, curbs, tracks, manholes and catch basins, as well as on every other point upon which levels might have been taken in years past, for comparison with the old elevations. The area of settlement

* These tests are omitted here, as they were described by Mr. Gow in his discussion, p. 180.

proved to be about one square mile in extent with a maximum settlement of about two feet in the center analogous to a large, shallow saucer, with zero settlement at the perimeter.

Some fifty miles of bench levels were run to tie up with benches of undoubted permanency, some of which were situated two or more miles away on the solid hilly formation in the western part of the city near the Harvard College Observatory, and others some two miles farther away near the Belmont town line.

Engineers from the Metropolitan Water and Sewerage Board corroborated the settlement, finding that the Metropolitan Sewer through Cambridge had gone down two feet at the maximum point.

When the surveys for the Boston Elevated Railway Company's extension to Cambridge were made in 1901, further information was obtained, which, when compared with the levels previously taken by the writer, showed a fairly uniform settlement of something over an inch a year at the maximum points. In succeeding years, 1906 and 1909, other parties from the Boston Elevated Railway Company have further corroborated the settlement, ascertaining that the rate of settlement is unabated and shows no promise of lessening.

Heavy structures on pile foundations, light wooden buildings, curbs, street railway tracks and sewers all go down at the same rate, viz., 1 to $1\frac{1}{4}$ ins. per year in the center of the settled district.

The writer's interest in this settlement was intensified when, as designing engineer of the Boston Elevated Ry. Co., with the late George A. Kimball, chief engineer, the author, Mr. Jos. R. Worcester, consulting engineer, and Mr. Chas. W. Mills, also consulting engineer, he designed the arch section of the Cambridge Main St. Subway in Main St., from Kendall Square to near Austin St.

Mr. Fred B. Edwards, division engineer of the Boston Elevated Ry. Co., under whose supervision the borings for the subway were made, devised a kind of geological profile interpreted from the wash borings. On a copy of this profile the writer plotted the various profiles of the surface of the street taken in 1869, 1897, 1901, 1906 and 1909, showing the progres-

diggers reported the same experience in the vicinity of the subway borings.

With all this information at hand the writer's design of the invert for the subway previous to excavation provided for a uniform distribution of the weight of the loads from the side walls over the whole width of the subway which resulted in an invert of considerable thickness. The excavation for the subway revealed the actual character of the clay upon which the invert of the subway was to rest, and with the bearing power experiments made with test piles indicated without doubt that the "crust" of harder blue clay could be depended upon to support the subway side walls and invert without the uniform distribution which had been thought necessary before the clay bottom was exposed. The depth of invert was accordingly reduced about one half.

Fig. 1, page 194, is a map of the settled district. Fig. 2 is a profile through Main St., Cambridge, with a study of the geological strata as indicated by wash borings made in 1906. Bed rock has been sounded at a depth of from 90 to 100 ft. below the surface, with indications of a thick layer of very soft clay on top, though wash borings are not to be entirely depended upon, as has been revealed by the actual excavation for the subway proper. It was found that "soft blue clay" near the surface was a misnomer, when actual excavations for the subway were made, and that the crust of harder blue clay was thicker than had been judged from the wash borings. Soft clay may, however, exist down next the bedrock.

Above the main profile a greatly exaggerated set of profiles is given of the various lines of levels run by City Engineer Chase in 1869, on the establishment of a legally accepted grade; by the writer in 1897 at the time of the discovery of the settlement, and by Messrs. Herman Gregg, H. H. Hawkesworth and W. L. Learned, assistant engineers, Boston Elevated Railway Company.

Tables I and II list a typical set of observed settlements at different dates.

Most of the Cambridge Subway invert, which is from five to ten feet below mean low water, is laid in blue clay. A

TABLE I.
ELEVATIONS AND SETTLEMENT OF BENCH-MARKS IN CAMBRIDGE.
(Compiled from City Engineer's Note Books.)

Date.	Main St. and Mass. Ave. Orne's Cor.	Main St. cor. Columbia St.	Mass. Ave. Moller's Bldg.	Odd Fellows' Bldg., Mass. Ave. opp. Norfolk St.	School St. cor. Windor House.	Washington St. and Columbia St.	Swedish Church.	Mason & Hamlin's, Broadway at Burleigh St.	Closes, Broadway and Windor St.	Main St. and Albany, Ivers & Fond.	Metropolitan Stor- age Warehouse, Mass. Ave.	Harvard Bridge Abutment, Mass. Ave.	Reardon's Factory, Waverly St. and Talbot St.	Brookline St., cor. Pilgrim St.	Central Sq. Hydrant.
1876.	.....	21.324	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1885.	*21.284	21.228	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1889.	†21.084	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1897.	20.711	20.744	.....	24.679	.....	.....	.....	.....	.....	.....	.....	26.033	22.547	20.320	31.144
1898.	.....	.....	.....	.....	19.712	.....	.....	19.198	21.971	20.637 (?)	21.765	25.870	.....	20.365 (?)	.....
1899.	.....	20.621	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1900.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1901.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1902.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1903.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	21.118	.....	.....	20.382 (?)	.....
1904.	19.876	19.771	20.187	{ 24.243 24.210	19.320	.....	.....	.....	.....	.....	21.056	25.876	.....	.....	31.140
1905.	.....	.....	20.171	.....	.....	21.113	.....	19.119	21.831	20.570 (?)	21.047	...	22.550	.....	.....
1906.	{ 19.667 19.654	19.551	19.956	24.110	{ 19.133 19.097	21.043	.....	19.055	21.788	20.502 (?)	20.843	.....	22.460 (?)	.....	.....
1907.	19.593	19.485	19.894	24.069	19.086	21.062	.....	.....	.....	.....	20.847	25.800	.....	.....	.....
Total.	1.691	1.839	.850	.610	.626	.051	.....	.143	.183	.135 (?)	.918	.233	.087 (?)	.....	.....
No. of years.	22	31	10	9	9	2	.....	8	8	8	10	18	17	6	7

Question mark (?) indicates doubtful measurements.
* 1895.
† 1901.

TABLE II.

COMPARISON OF BENCH ELEVATIONS, CAMBRIDGE CITY ENGINEERS' LEVELS AND BOSTON ELEVATED RAILWAY COMPANY LEVELS.

BENCH.	ELEVATIONS BY CITY.								ELEVATIONS BY B. E. RY. CO. CITY BASE.				
	Sept., '85.	March, '91.	March, '98.	Aug., '99.	Oct., '99.	March, '04.	Nov., '04.	March, '05.	March, '06.	April, '07.	Aug., '01.	June, '06.	Feb., '08.
Standard near Old City Hall	30.208	30.208	30.208	30.208	30.208	30.208	30.208	30.208	30.208	30.205	.....	30.214	30.241
Hydrant spindle, Central Sq.	.....	.....	.....	.....	.....	31.105	31.141	.....	31.108	31.117	.....	31.132	31.120
Bolt in Odd Fellows Hall Building	.....	.....	24.679	24.586	.....	24.243	24.210	.....	24.123	24.069	.....	.....	24.038
East end stone step, No. 545 Mass. Ave.	.....	.....	.....	.....	.....	.....	25.439	.....	25.348	.....	.....	.....	25.215
Southwest cor. step, No. 509 Mass. Ave.	25.236	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Stone bound at Orne's Corner	21.284	21.084	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Stone bound cor. Main and Columbia Sts.	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
Bolt in Moller Building	.....	.....	.....	.....	.....	19.771	.....	.....	19.554	19.485	.....	.....	19.441
Buttress entrance W. M. Church, Columbia St.	.....	.....	20.744	20.621	.....	20.171	.....	.....	19.956	19.894	20.425	19.994	19.844
Bolt in Boardman School, Windsor St.	.....	.....	.....	.....	.....	.....	.....	.....	20.665	.....	.....	.....	20.624
Bolt in building cor. Main and Portland Sts.	.....	.....	19.707	19.611	19.609	19.320	.....	.....	19.113	19.086	.....	.....	19.056
Stone bound cor. Main and Portland Sts.	21.488	.....	.....	21.962	.....	.....	.....	.....	21.624	.....	.....	.....	21.615
Hydrant spindle cor. Main and Albany Sts.	.....	.....	22.847	.....	.....	.....	.....	22.271	19.571	.....	21.031	20.804	20.715
Bolt in Ivers & Pond Factory	.....	.....	20.637	20.534	.....	.....	.....	20.672	20.502	.....	.....	.....	*22.141

* Probably reset in the interval.

thin layer of sand underlies the subway invert on Main St. from Austin St. nearly to Massachusetts Ave., according to Mr. Robert B. Farwell, formerly division engineer for the Boston Elevated Railway on the construction of the Cambridge Main St. Subway, and further corroborated by the profile.

A copy of the profile showing the probable geological formation as deduced from the wash borings was in the hands of the construction engineers of the Cambridge Subway before and during construction. These engineers have since stated that this "wash boring" profile, shown in Fig. 2, was substantially confirmed in all but minor details by the subway excavations, for the depth made.

Mr. Farwell states that there was no evidence of any deposit of peat anywhere near Lafayette Square or in Massachusetts Ave. from the surface of the ground to the bottom of the subway excavation, much less on the invert. (Lafayette Square is one of the points of maximum settlement.) Prof. W. O. Crosby informs me that to his knowledge clay sometime overlies a deposit of peat.

Not one of the Cambridge Subway borings, however, gives any indication of a deposit of peat underlying the clay. It is well known that wash borings are not to be depended upon with any certainty, but it may reasonably be inferred that at least some of the borings would have indicated peat had such an underlying deposit existed.

There are profiles of all the streets in the sunken part of Cambridge on file in the City Engineer's office in Cambridge, substantial evidences of the extent of the settlement, showing both old elevations previous to the sinking, and the grades established in 1897, in conformity with the new elevations of the surface of the streets.

From the map (Fig. 1, page 194), it is reasonable to conclude that the subsidence of the Main St. District is a local phenomenon as compared with the slower one of much greater extent, referred to by John R. Freeman in his report on the Charles River Dam. There seems to be a general subsidence of the entire Boston territory, and probably of a large part of the North Atlantic coast, with reference to sea level. The report

presents this matter fully, as concerns the Boston region. The following paragraphs quoted from the appendix to that report, written in 1903, state the facts briefly:

" All of the territory in and about Boston is probably slowly sinking relatively to the level of the sea. Apparently this subsidence is at the rate of about one eighth of an inch per year, one inch in eight years, or a little more than a foot in each one hundred years.

" This is obviously a question of great importance in comparing ancient soundings with modern, and in considering the possible future shoaling of the harbor.

" The present datum plane to which all elevations are referred by the engineering department of the city of Boston, and which is commonly known as 'Boston Base,' probably coincided almost exactly in the year 1830 with mean low water at the Charlestown Navy Yard. Prior to the Miner levels of 1878 the Boston datum had always been supposed to be at mean low water, and was so marked on the plans made by the city up to 1878.

" In 1878 Boston Base was found to be about 0.64 ft. below mean low water as determined by the United States Coast Survey at some time just prior to 1870.

" To-day, after the lapse of seventy-two years, this same datum plane, as defined by numerous bench marks on solid ground, according to the best available determinations, is 0.79 ft. below mean low water.

" This comparison shows that the land now stands about 0.79 ft. lower relatively to the sea than it did about seventy-two years ago, and therefore shows that the land in Boston and vicinity is sinking at the rate of about one foot per hundred years.

" Making a similar comparison on the basis of mean sea level, instead of mean low water, we find the rate of change is 0.71 ft. in seventy-two years.

" This change affects a very large area, and a variety of independent proofs is offered.

" At this rate, the present grade of Atlantic Ave. near foot of State St. (15.0 Boston Base) will be awash by the spring tides of each month about two hundred and fifty years hence.

" The proofs of this subsidence in brief are:

"(1) The sills and floor of the masonry dry dock at the Charlestown Navy Yard now stand about 9 ins. (0.71 ft.) lower relatively to mean sea level than any did seventy-two years ago, while the dock stands at precisely the same level relatively to points on solid ground.

"(2) The comparison of sundry tide gages, ancient and modern, indicates progressive subsidence.

"(3) Many rocks about the edges of Massachusetts Bay are found to be from 1 to 2 ft. deeper below extreme low water now than they were about ninety years ago.

"(4) The extreme tides in great storms appear to show progress toward greater heights.

"(5) At many points about Boston tree trunks are found standing in salt marsh under conditions that prove a recent subsidence.

"I was led to investigate this matter by consideration of statements of Prof. W. O. Crosby regarding the geological causes which had formed Boston harbor, resulting in a submerged valley; and from my observation of the peculiar relation of the datum plane at present used by civil engineers on the Boston public works, known as 'Boston Base,' to the ancient datum plane of 'marsh level' and to 'mean low water,' and because of the unsatisfactory explanations offered as to why 'Boston Base' was established at the odd distance of 0.64 ft. below mean low water, I was led to investigate the old bench levels.

"I had for some years past been interested in the indication of comparatively recent subsidence found in the resemblance of some of our coastal indentations to ordinary valleys that had become submerged, and in studies as to the future water supply of Brooklyn (Report on New York Water Supply, 1889-90) I had occasion to review the proofs of recent subsidence offered by the State Geologist of New Jersey, and was therefore the more ready to follow out the indications of the present case."

The general subsidence which Mr. Freeman demonstrates has important bearing on elevations of harbor works, bridges, sewers and the like. On the other hand, the much more rapid local subsidence in Cambridge, above described, seriously affects the structural design and the grades of sewers, subways and other continuous underground structures crossing the district of movement.

C. T. FERNALD (*by letter*).—The careful and painstaking work and the important bearing which Mr. Worcester's paper will have on the design of foundations in and about Boston certainly entitled him to the thanks of the Society and of the engineers practicing in this community.

In my own experience I have found, however, one or two instances, possibly due to an error in judgment, where results have been at variance with the conclusions reached by Mr. Worcester.

Under the heading of "Summary of Recommendations," Item 1, Section B, — query is made "whether piles are likely to be an advantage, and if so, how long willt hey probably be?" My own answer to this would be, when in doubt use piles, as the correct answer to the above can only be determined when the bearing power of the soil is given its approximately safe value. As an instance, during 1911, in building the elevated structure connecting the Cambridge Bridge with the Beacon Hill Tunnel, the original soil, blue clay, on which the two most easterly piers supporting this structure were placed, was exposed. This blue clay might be classed as fairly hard, and the load it was to support on each pier amounted to 3.3 tons per sq. ft. One of them, however, the one toward the Charles River, began to settle shortly after its completion and continued to do so for nine months until it was 0.6 ft. below its original position. It was only after the footing of this pier had been increased in area from 231 sq. ft. to 522 sq. ft. and the load reduced to approximately $1\frac{1}{2}$ tons per sq. ft. that settlement ceased. The more easterly pier has never settled from the time it was built, yet the quality of the clay was apparently exactly the same.

Under Item 1, Section C, I think the conditions surrounding the building of a structure, or probably the sequence in which the work is done, have a great influence on its future stability. For instance, of the river piers of the Charles River Bridge, those which were built adjacent to the completed work of the Charles River Basin Commission have settled but very little, while those which were built prior to the completion of filling the dam settled from 0.1 to 0.33 ft. and tipped toward the dam or fill in proportion to the depth of the fill. Owing largely to this settlement, work on the completion of the superstructure for the bridge was delayed until the dam itself was filled to its final grade. There is no doubt, I think, from a study of the conditions, that all of this movement was due to the compression of the soft clay underlying the stratum of gravel on which the

concrete foundations were placed and through which the supporting piles were driven into the clay. A further settlement of the piers took place when the superstructure was added, but it was comparatively uniform throughout. The tendency to tip toward the dam was not continued when this superstructure was added.

Under Item 3, in my judgment grade 8 is as high as it is safe to cut off piles in filled land which is near tide water. The older buildings on Lowell St. at the West End are supported on piles cut at grade 11. In cases where elevated foundations were built adjacent to these buildings some of the old piles were exposed and were found to be entirely rotted from the top down to about grade 8, at which elevation they were comparatively sound. In some cases we were forced to renew these piles above grade 8 to make the structure as safe as it was originally. At the old site of the Hendricks Club, corner of Causeway and Lowell Sts., piles cut at grade 8 supporting the old structure were found to be sound and were counted upon to assist in the support of the new structure recently erected there. On Beach St., just below Harrison Ave., adjacent to the elevated structure, the owner of a building claimed that the dangerous cracks and settlements were due to the construction of the elevated structure. An investigation of the foundations for this building, however, disclosed piles supporting the front and side walls cut at about grade 10.9, and their tops for a foot or more below this were entirely rotted away and of no value. Below this latter point, however, they gradually grew better so that at approximately grade 8.5 they were in fairly sound condition. In all of the above instances the piles were driven in filled land which at one time was under water. In my judgment it will not be safe to cut piles above this grade except possibly where they were near enough to tide water to be affected by the full range of the tide.

Under Item 4, from my experience noted under the heading of Item 1, I should be inclined to assume as the safe bearing power for medium blue clay, 3 tons, and for soft clay, running sand (confined), 2 tons.

Under Item 5, as to the supporting power of the piles, if we are prepared to accept the settlement of $\frac{1}{4}$ in., which I think is

reasonable in any structure, the modification in the *Engineering News* formula for the safe supporting power of the piles, as suggested by Mr. Worcester, is conservative. In January, 1900, while the Lincoln Power Station was under construction, tests were made of two piles 35 ft. and $29\frac{1}{2}$ ft. long respectively, which were driven into the stiff blue clay and sand, leaving 4 ft. above the ground. The total penetration was 23 ins. and 22 ins. respectively in the last ten blows with a 1 800 lb. hammer and a 31-ft. drop.

By the old *Engineering News* formula these piles were good for 16.9 tons, and by the modified formula they would be reckoned as good for 25.36 tons.

Load.	Settlement.	Load.	Settlement.
14.83 tons.	.003 ft.	16.13 tons.	.001 ft.
23.07 tons.	.01 ft. *	20.84 tons.	.025 ft.
33.30 tons.	.045 ft.	28.01 tons.	.051 ft. *
39.58 tons.	.055 ft. (failed).	28.73 tons.	.059 ft.
		30.48 tons.	.075 ft.
		33.06 tons.	.087 ft. (failed).

The above tabulation shows the settlement occurring as the added loads were applied, the failure being caused by the splitting of the pile above the ground, and it will be noted that the settlement in both of these piles for a loading approximating that calculated by Mr. Worcester's formula is very close to the $\frac{1}{4}$ in. reckoned.

HARRY E. SAWTELL (*by letter*).—Permit me to express admiration for Mr. Worcester's paper, and in presenting this discussion it is hoped that a little of value may be added to it.

Referring to five tests of piles recently made at the new site of the Massachusetts Institute of Technology, and given in Mr. Worcester's paper as numbers 10 to 14, it is noticed that the total length in the ground is given with no further information as to how much of the length is through fill and what part is in the harder glacial deposit. The writer thinks it will assist in gaining a more complete understanding of these tests if the amount of penetration into the firmer glacial deposit is given.

* Approximates J. R. Worcester's formula.

	Total Length in Ground. Feet.	Length in Glacial Deposit. Feet.
No. 10.....	28.7.....	About 12.0
No. 11.....	32.08.....	About 17.0
No. 12.....	41.6.....	About 22.0
No. 13.....	26.7.....	About 14.0
No. 14.....	23.6.....	About 11.0

It will be seen that only about one half of the length of these piles rests in the reliable stratum. Before reaching it the piles passed through fill, mud, silt, etc., of a very unreliable character.

These facts will affect the showing made by these piles in Mr. Worcester's table wherein are found "coefficient lbs. per sq. ft.," as it appears to the writer better to use the actual lengths of embedment in the hard soil rather than the whole length, including a soft fill, silt, mud, etc.

The writer agrees with Mr. Worcester that the method of arriving at the value of piles by a surface coefficient is uncertain, not only because of the inability of determining at all times the length to consider, but also on account of variable character of the soil through which the pile may be driven.

Without question borings should be made to assist in ascertaining not only the depth and character of the firm subsoil, but also of the fill. It is the writer's belief that owing to the fact that the character and levels of the sub-strata change within a few feet in many localities in the Boston Basin, borings in a site should be made quite close together in order to be of full value.

This quick change of character and levels of strata has been particularly noticeable at the new Technology site, and has frequently necessitated using piles of as much as 25 ft. of difference in length within short distances. Under such conditions it should not be expected that anything more than approximate knowledge of the sub-soil would be gained with borings placed 200 to 300 ft. apart; 25 to 50 ft. would be better.

The danger of being misled is great when driving piles through a hard fill into a desirable sub-soil, as the resulting formula load does not give true results but too high ones. Piles driven through hard fills are not ordinarily given much penetration into the good, firm soil under the fill, and consequently

have a small true value, and as most fills contain a large percentage of matter which will decompose, shrink in volume and settle, it will by friction on the pile surfaces add to their load and cause settlement. The above condition is a fact more frequently than it should be and emphasizes the necessity of full knowledge of the soil.

The writer wishes to call attention to the desirability of giving piles a deep embedment when driving into most kinds of soft sand or silt and sand containing water, as it has been noticed that, while a formula value may be obtained soon after penetrating the sand a few feet and which cannot seem to be raised by further driving, it is noticed, however, that those piles having the deeper penetration show the greater capacity and less settlement when tested by load. This undoubtedly is because when driving the pile the soil around it is agitated and kept in a more or less liquid state, offering a lessened resistance, but after coming to a state of rest the resistance increases very largely and the greater the length of pile, the greater the gain in value. Different authorities have spoken of this gain after the soil has been allowed to rest and become compacted, but such tests appear to have been in other sections of the country. It would be of value if we could get an idea of what it would be from tests for a typical Boston soil.

It is noticed that Mr. Main in his discussion speaks of pulling test piles for the purpose of determining their suitability for the proposed site, and further makes the statement that it had been found that spruce piles were suitable for soft driving only.

This is of importance, and will largely obviate the necessity of depending upon the contractor's judgment as to what are good and bad piles. The knowledge gained from borings and test piles pulled will enable the engineer to place pile foundations with a degree of surety impossible otherwise. Too many piling jobs are done based on the piling contractor's judgment rather than on an engineer's judgment.

Test piles which have been pulled at the Technology site have shown conclusively that when piles are to depend largely or wholly on point bearing in a hard stratum, spruce should not be used, for they break, deflect and break or broom to such an

extent as to be wholly unreliable. Spruce may, however, be used without danger in softer driving where dependence is placed on friction for its value.

Hard driving may be defined for wood piles having 6 ins. or smaller points as less than an average penetration of $1\frac{1}{2}$ ins. for the last three or four blows under a 2 300 lb. hammer at a 10 ft. drop, and soft driving would be secured when the penetration was greater than $1\frac{1}{2}$ ins. under the conditions as outlined above.

Regarding Mr. Worcester's proposed change in the *Engineering News* formula, the writer would regret to see it made, as he believes, first, that it would result in greater settlements under working loads; second, from long observation it is believed that a large part of the piles driven are, unlike test piles, seldom given the penetration required which now results in doing what Mr. Worcester would do by changing the formula; third, that an unknown percentage of spruce piles driven under the present conditions are unreliable, due to brooming and breakage; fourth, that as this construction is out of sight, a greater factor of safety should be obtained than for construction in sight which can be inspected; fifth, that the factor of safety obtained by the *Engineering News* formula is now relatively low when based on a reasonable settlement of the pile itself. This was brought out by Mr. Worcester in his paper.

In regard to Mr. Worcester's suggestions for safe bearing pressures on soil, the writer thinks that $2\frac{1}{2}$ tons per sq. ft. is excessive on "soft clay, running sand (confined)," owing to the difficulty of really getting a permanent confined condition in actual construction.

Having in mind Mr. Worcester's statement that he does not wish to continue the work of "Boston Foundations," and believing that it is a very important and valuable work to Boston and vicinity, the writer hopes that the Boston Society of Civil Engineers will appoint a committee to carry on the work and thus increase the knowledge of a subject very important to the city of Boston.

LESTER W. TUCKER (*by letter*). — Mr. Worcester's paper is most interesting and instructive to the engineers who have been

engaged in foundation construction in the city of Boston and vicinity. The writer is especially interested in the chapter on ground water level and wishes to add a personal experience on this.

After the leasing of the Fitchburg Railroad by the Boston & Maine Railroad in 1900, it was decided to remodel the old Fitchburg station, making it over into an office building, and the writer was in charge of the work.

In putting in some new foundations near the outside walls it was found that some of the piles under the walls of the station were badly rotted at the tops, and a careful examination of these foundations showed that the piles had originally been cut off at grade 10 and the stone foundations built directly on these piles. They were driven in two rows about 30 ins. on centers, staggered, except under the wide pilasters, where they were three rows instead of two. The piling was oak or chestnut, there being practically no soft wood piles under the building. The top 18 ins. of many of these piles was badly decayed, there being scarcely enough good piles left to support the walls. These piles had been driven in 1847 and so had been in place fifty-four years, with cut-off at practically mean high water. The filling around these piles was dump material and very porous, so that the piles were completely saturated at every high tide. A careful examination of the piles showed them to be in good condition at grade 7, and in reconstructing the foundations they were cut off at this elevation. This experience would seem to indicate that we are not warranted in using a cut-off grade much higher than grade 8, and it is the writer's opinion that Mr. Worcester's question whether grade 8 would not be a reasonably safe assumption for low ground water level is practically right for those parts of Boston which are near enough tide water to be affected by the rise and fall of the tide. It is the writer's belief that grade 9 or 10, which has been adopted for so many of the cut-offs in the vicinity of Boston, is high and that we are not warranted in using anything better than grade 8 for this cut-off.

GRANVILLE JOHNSON (*by letter*). — Mr. Worcester mentions certain cases where the water level varies from that naturally to be expected. I had some experience with a similar case

at the corner of Massachusetts Ave. and Windsor St., Cambridge, opposite the old bicycle track.

The building on the land was started in September, about two years ago. The grade of the Basin is, and was at that time, I believe, approximately grade 13.00, and at that time some parts of the land were at approximately grade 12, Cambridge base. The land was free from water. The grade of the top of the basement floor is 12.25. The floor is of reinforced concrete and is not waterproofed. In the spring some leaks developed at the joint between walls and floor, during and after fairly heavy rains. The joints were then waterproofed.

I believe there have been no leaks through the floor, which I should expect if there were a head of water upon it. The sewers sloped toward Boston. At the corner of Windsor St. and Massachusetts Ave. they are at grade 11.50. The foundations of the building rest on coarse gray sand from three to seven feet below grade 12. I have not been able to find from our records at just what grade the water level was when the excavations for the foundations were made. I believe, however, that it was below grade 11.

I agree heartily with Mr. Worcester in his recommendation as to the advisability of making borings. I have had a case recently in Worcester bearing on this. Test pits showed 7 ft. of miscellaneous filling and then coarse sand, apparently an excellent bearing material. Borings showed miscellaneous filling, then ten to twenty feet of sand, and then in places three to four feet of silt.

I believe Mr. Worcester's recommendation for the safe load on confined saturated sand to be lower than need be in many cases. I have found very fine sand to sustain a load of nine tons per sq. ft., with a settlement of not more than $\frac{1}{8}$ in under test.

BOSTON SOCIETY OF CIVIL ENGINEERS
FOUNDED 1848

PAPERS AND DISCUSSIONS

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ADDRESS AT THE ANNUAL MEETING, MARCH 18, 1914.

REQUISITES FOR SUCCESS IN ENGINEERING.

By FREDERIC H. FAY, PRESIDENT, BOSTON SOCIETY OF CIVIL ENGINEERS.

THE custom of presenting an annual address by the President, now common in all of the national and the larger local engineering societies, doubtless had its beginning in this country in the American Society of Civil Engineers, where originally the president was required to give a review of the progress of engineering during the preceding year. With the rapid development and tremendous broadening of the engineering field it became necessary to modify the custom, and instead of attempting to present a comprehensive survey of the advancement in engineering, the president found it necessary to confine himself to some particular engineering topic.

In what I have to say to-day you will find little that has not been said before, often in an abler way, but I wish to speak of some fundamental points which I believe should be constantly borne in mind by every engineer who seeks to advance the interests of himself and his profession. Particularly do I desire to speak to the younger members of the Society, who in due time will be called upon to take up the burdens and responsibilities now carried by their seniors, and who must in their turn become leaders of the profession.

The future of engineering is bright. Opportunities are expanding. The world is coming to expect and to demand a higher

standard of the engineer and of engineering. The younger members especially should be alive to the situation. They should foresee what the future has in store, and they should endeavor to so train themselves that they will be prepared to seize the opportunities as they are presented, and be fit to assume the greater responsibilities that are coming, and are bound to come, to engineers.

THE OUTLOOK.

The profession of engineering is the oldest of all professions, and dates from the earliest and most elementary civilization; but it is only within comparatively recent years that it has become recognized as a distinct profession, and we must still look to the future for that full recognition to which we engineers believe the profession is entitled. Upon no profession does the world depend so much for its advancement as upon the profession of engineering — and I use the term in its broadest sense.

The material progress of the world is being advanced in three broad fields of activities, — production, transportation, and what some call our “communal relations”; that is, the activities consequent upon the gathering together of people in communities, towns and cities. In each of these three fields the engineer is a most important factor, and in each the progress achieved depends more than anything else upon the advancement made by the engineering profession.

Take production of commodities and we find that practically every activity in this field depends upon the work of the engineer. To begin with, in order to produce something, mankind must have materials to work upon. These must be obtained from the soil, as by agriculture or forestry, or from the depths of mother earth, as by mining. In all of this work the engineer is much in evidence, for even the success of modern agriculture is to-day largely dependent upon machinery and the implements which engineers produce, as well as upon irrigation. To change raw materials into finished products it is necessary to develop and utilize power in various ways, and here the engineer is especially useful, from the mining of coal and the building of dams to the construction and operation of power plants. The

power thus obtained is utilized in a multitude of machines which transform raw materials into manufactured products necessary or useful for the comfort and well-being of mankind, and the development of machinery in all of its forms is the work of the engineer.

As production passed the point of supplying merely the needs of bare savage existence, there was developed the important field of transportation — the movement of people and commodities from one place to another by land and by sea, and (in the present century) by air. In order that there may be transportation, routes have to be provided, necessitating the building of highways, railroads, canals, bridges and the like; vehicles of various kinds are required, as wagons, automobiles, the rolling stock of railroads, and ships, and for most of these special means of mechanical propulsion are necessary. With the growth of transportation, great land and water terminals are built and equipped with various devices for the expeditious and economical handling of passengers and freight in large quantities. Under the heading of transportation we may include, too, the transmission of intelligence by telegraph and telephone. The whole broad field of transportation has been made possible only by the work of the engineer, and to him the world looks for all future progress.

The development in the fields of production and transportation have made necessary the gathering together of people in towns and cities, and existence in such communities would not be possible were it not for the engineer. The larger the community, the more necessary and the more important and complicated does the engineer's work become. Cities cannot exist without systems of water supply and sewage disposal, the construction and maintenance of streets and pavements, the disposal of wastes, and the introduction of central systems for supplying light, heat and power; and in communities of any considerable size the development of means of internal communication by street railways, elevated railways and subways, all of which latter really belong to the broad field of transportation.

The world's advance in these three great fields of activity has been slow and gradual until within a comparatively brief

period, when progress in these lines has made wonderful strides. There are members of the Society who have been eye-witnesses of the tremendous advance in the past sixty or seventy years. Will the world's progress which made such a wonderful start during the nineteenth century be checked during the twentieth? Will the rate of advance during the lifetime of our children be any less wonderful and rapid than it has been in the lifetime of our fathers?

Of all the professions, the profession of engineering, in its broad sense, contributes most to the welfare and advancement of mankind. Even far more important than the medical profession is the profession of the engineer, for while medical men seek to cure disease, the sanitary engineer is constantly at work to prevent it. In every field of activity the world is coming more and more to depend and rely upon engineers; and, as the field has grown and broadened during the nineteenth century, so I believe will it continue to grow and broaden during the twentieth. But to meet these demands engineers themselves must grow and become broader men. The successful engineer of to-day and of to-morrow cannot be like the engineer of yesterday, who too often would "retire into the technical recesses of his professional work and content himself with being the servant of other men." On the contrary, if he would stand high in his profession, the engineer of to-day should be a broad-gage man, aggressive, alert, in touch with public questions outside his own narrow field, and a leader — not a follower — of men. It is upon the development of these qualities in engineers themselves that the whole future success of the profession depends, as well as to a considerable degree the advancement and the material progress of the world during the twentieth century. As a president of the American Society of Mechanical Engineers recently said, "Engineering is the profession of the present and will dominate the future." This will be true provided engineers themselves wake up to their opportunities and fit themselves to assume the greater responsibilities which the world is ready to place upon them.

THE TRAINING OF THE ENGINEER.

What are the qualities which fit a man for success in the profession of engineering? The ideal engineer must be a scientific man and at the same time a business man. To quote from an article by one of the past presidents of this Society¹: "He must have a thorough knowledge of the laws of nature, the fundamental principles of mathematics and mechanics, and the materials of construction, for his work consists in applying those laws, principles and materials so as to make them of use in the world's business. He must be essentially a man of action. The engineer takes the discoveries of the scientist in his laboratory, or the bookworm in his study, and makes them available for the use and convenience of man. His dominant quality must be practical common sense, combined with habits of care and accuracy, and with the courage and training which will enable him to solve new problems and to meet emergencies with success." To these qualities I would add the quality of imagination. A recent president of the American Society of Civil Engineers² has said: "We do not consider imagination, ordinarily, as an important quality in the engineer, yet I think no engineer ever rises to eminence in his profession without it. Ex-President Eliot of Harvard, one of the most eminent educators in the world, says it is just as important to the engineer as to the artist and literary man, and that the engineer should stand with his feet on the ground and his head in the skies."

The foundation of an engineering career should preferably include a good technical school training, although this is not absolutely necessary, and we find that many of the most successful engineers of to-day are men who began their careers as apprentices in an engineer's office, gaining experience and studying at the same time. Much can be accomplished in this way by the novice in engineering, provided he finds employment with the right kind of an engineer, and provided also that he has the pluck and strength of character to apply himself assiduously to study in connection with his engineering work. Too often these men

¹ Geo. F. Swain: "Engineering. Civil," *Encyclopedia Americana*.

² Mordecai T. Endicott; *Trans. Am. Soc. C. E.*, Vol. LXXIII, p. 395.

fail because of lack of "stick-to-it-iveness." Independent study of this kind is necessarily slow and usually unbalanced and incomplete, and the young man seeking to enter the engineering profession will find a great economy of time as well as much greater breadth of training if he take a course in a technical school. No amount of schooling alone will ever make an engineer, however, and unless he have other qualities than the mere faculty of assimilating knowledge, the young man will fail as an engineer in spite of the best technical training; while, on the other hand, the man without the training of a technical school, but who possesses these qualities, will achieve success in the profession.

The best technical school training is one which gives a thorough grounding in the fundamental subjects of science and engineering without frills and specialties. Too often the young student seeks to get in a four years' engineering course a highly specialized training in some particular engineering branch. In response to popular demand there has been in most of our technical schools, during the past few years, a tendency to too high a degree of specialization. Fortunately a reaction is setting in, and in the best technical schools to-day courses are being rearranged so as to give the student a more thorough training in science and the general principles of engineering, with less specialization. It is a very common thing for the young engineer on leaving a technical school to enter a different line of work from that which he had in mind when he began his work as a student. This is so common that it may almost be said to be the general rule. With a thorough grounding in general principles in a technical school course there is no reason why the young engineer, by his own efforts in after study, should not fit himself for successful work in any branch of the broad profession of engineering.

Thorough preparation in the fundamentals of science and engineering is, however, but a part of the training necessary for the young man who is to become a successful engineer. In addition, much time should be given to the study of those subjects of a general nature which are necessary for every thoroughly educated man. "The engineer of the past has too generally

been considered a mere builder, and he has not as a rule been given the position to which his responsibilities and his achievements legitimately entitle him; but the engineer of the future should aim to take a position in society and business as a cultivated and highly trained man, on a level with men in any of the other professions."¹ The young engineer should have a general knowledge of business, "for engineering is business and business is engineering," and this may be obtained in part in the technical schools by a study of economics, business law and business methods. Some knowledge of the laws of business, and especially of the laws of contracts, is absolutely essential to every engineer who finds himself in charge of important engineering work.

There is one quality of highest importance to the success of the young engineer, which cannot be taught in schools and which he must gain for himself, and that is the ability to properly meet and mingle with his fellow-men. In other words, he should be what is popularly known as a "mixer," and failure in this direction is responsible for the lack of, or limited, success of many an engineer who has the other requisites, and who but for this lack would undoubtedly achieve a far higher position. "To be an engineer of material only is to be but a subordinate element in a profession which has contributed, and will continue to contribute, more to the advancement of civilization than all others combined. Rather should he strive to become an engineer of men."²

In a recent presidential address delivered before the American Society of Civil Engineers³ it is stated of the engineer: "His training and practice have taught him to regard himself as separated from his fellow-men, with the result that he becomes the tool of those whose aim is to control men and to profit by their knowledge. The end is that he is a servant where he should be a master. Herein lies the weak point in the profession — may I be pardoned for naming it professional narrowness, while I try to point the way to convert weakness into strength. It is

¹ Geo. F. Swain: "Engineering. Civil," *Encyclopedia Americana*.

² Charles Macdonald; *Trans. Am. Soc. C. E.*, Vol. LXI, p. 546.

³ Onward Bates; *Trans. Am. Soc. C. E.*, Vol. LXIV, p. 573.

necessary for the engineer to be more of a 'mixer' than he has been, and to assume the initiative in many cases in which under similar conditions he has been a follower. He should be a manager, and should give orders to others who can do the work under his direction as well as he himself could do it with the situation reversed. It should not be considered unprofessional for an engineer to be a capitalist, and, when he takes his proper place as promoter and organizer and shares in the profits of engineering enterprises, he will no longer be taunted with the saying that 'an engineer is only good to spend other people's money.' It is by acquiring individual strength that the engineer can give strength to the profession. It is well known that engineers of admitted proficiency often have to work under the direction of men who are unfitted by education and experience to direct engineering work. This is because the engineer is a workman while the other party belongs to the class of 'managers.' The engineer has not reached his proper rank until he can hold the position of manager, as well as that of a designer and supervisor of work. This is no plea for titles, since no title is more honorable than that of engineer, but it is a plain statement of present conditions. A better position will be secured whenever the engineer makes it his business to study men as well as materials, and to use men as he does machinery. The advancement must be individual, by fitting oneself for commanding duties, assuming those duties, and 'making good' in their performance."

In other words, engineers should not study nature alone but they should also study human nature. The higher an engineer rises in his profession, the more must he rely upon the work of others and the more will he come in contact with men in other professions and other walks of life. The engineer's success will then be measured by his ability to select competent assistants and advisers as well as by his ability to meet other men, to understand their points of view, and to present his views in terms which they can clearly understand. No engineer can successfully meet these requirements unless he begins young to mix with his fellows, not only with those in his own narrow special line of engineering work, but with others throughout the broad field of

his profession and especially with men in various other walks of life.

THE PUBLIC AND THE ENGINEER.

The feeling is general among us that the public does not sufficiently appreciate the value of the work of engineers, and does not give the engineering profession the recognition to which it is due. As an engineering friend of mine¹ recently expressed it: "In the bucolic mind, the land surveyor and the engineer are one, and the locomotive runner or the man who runs the mill is looked upon as rather a higher type of engineer. To most people the name — engineer — applies to all men who operate steam or electric machinery or who survey land equally with those who locate and construct railroads, design bridges, water-works, sewers, etc., and direct the multitudinous activities connected with the complex civilization of the twentieth century. They confuse the engineer proper with the mechanic, artisan and skilled laborer, holding us, perhaps, a littler higher than the rest. The public associate the engineer with construction as they see it going on before their eyes, in buildings, bridges, sewers, etc. They do not distinguish between the superintendent, who may be and often is an engineer, and the foreman of a gang. An instrument man giving elevations represents the typical engineer to them far more definitely than would a sight of the chief in his office working over his plans."

The otherwise intelligent public has little or no conception of the importance and magnitude of the office side of engineering work. For example, if city authorities lay out a street and make an appropriation for its construction, it is hard to understand why a contract for the work cannot be let the next morning, and actual construction begun immediately. Or, if a bridge is to be constructed, what is to hinder calling in the representatives of bridge companies and saying to them, "We want a bridge so long and so wide to carry such and such loads. What will you build it for?"

The idea that to secure economical results it is necessary

¹ Edward E. Wall: "The Status of the Engineer," *Journal Assn. Eng. Soc.*, Jan., 1914.

to carefully plan work of this sort in the office before calling for bids and beginning actual construction, is foreign to the average lay mind.

To the engineer the lack of appreciation by the public is frequently painfully apparent, particularly when measured in terms of dollars and cents; but are we not ourselves largely responsible for this situation? The general public can learn of the qualities of engineers and the work that they do only from stories written by the reporters of local newspapers, and in the public press to-day, except for some notable undertaking like the Panama Canal, the work and achievements of engineers receive far less newspaper space than is given to members of other professions and other callings. The chief reason for this, I believe, lies with engineers themselves. They are far too content to keep in the background. They are accustomed to doing things and not to writing or talking about them. They seldom take an active interest in the questions of the day, local, state and national, and rarely do they participate, as they should, in public affairs. The architects are ahead of the engineers in that through their professional societies they apply themselves to problems affecting the public welfare, particularly to city planning, and to many public questions concerning the development and improvement of our cities, especially along artistic lines; but how much greater is the opportunity for collective work along similar lines by engineering organizations!

"Practically everything of a communal nature that appertains to the comfort, convenience, luxury and necessity of the dweller in cities — all, in fact, that makes possible the existence of cities — is the work of the engineer."¹ Is it not the duty of the engineer, even more than of the architect, to study these questions in their broad sense, and to take an active part in promoting the welfare of the community as a whole? The engineer of ability, experience and success in his profession should be considered as large a factor in the life of his city as the lawyer, merchant, banker or physician.

In another way, I regret to say, are engineers frequently responsible for the low estimate which the public places upon

¹ Edward E. Wall: "The Status of the Engineer," *Journal Assn. Eng. Soc.*, Jan., 1914.

the value of engineering services. Chief engineers of corporations and public boards too often make the mistake of hiring engineering assistants at the lowest possible wage, under the false impression that by such rigid economy they are enhancing their own value in the minds of their employers. Many of us can name instances where young engineers of much ability and good training, but of somewhat limited experience, have been placed in charge of important pieces of work at salaries less than the lowest wage paid to skilled workmen employed by the contractors working under their direction. Such practices do grave injury to the whole profession and cheapen it in the estimation of the public. Furthermore, they tend to react to the disadvantage even of the chief engineer, for his employers will reason that if the rank and file of engineers can be hired so cheaply, engineers as a whole are a cheap lot, and high salaries are not necessary in any grade, even that of the chief engineer himself. "Cheapening men ultimately means inferior work, which is bound to result in breaking down the standard of the profession."¹ It may be argued that salaries are regulated by the laws of supply and demand, yet the chief engineer who pays a fair wage, taking account of the time and money which the young engineer has spent in securing his education and training (his working capital), will not only secure better, more loyal and more efficient service, but will help to raise the standard of the whole profession, his own included.

THE WORK OF THE BOSTON SOCIETY OF CIVIL ENGINEERS.

In the presidential address delivered before our Society two years ago, it was stated, "It is time that this Society, which is a strong one, should make itself felt to a much greater degree in public enterprises, in the forming of public opinion, and in the various phases of our government." In this and in other ways I believe that the Society can do much to advance the standing of the engineering profession and the welfare of its members. The Society, it is true, is but the aggregation of its individual members, but if, individually, we come to realize the necessities of the situation, and the opportunities for improvement that lie

¹ Edward E. Wall: "The Status of the Engineer," *Journal Assn. Eng. Soc.*, Jan., 1914.

before us, we may, by concerted action, succeed in raising to some degree the standard of the engineering profession in the minds of the public in this community.

Perhaps the first step to be considered is that of publicity, and in this connection the Cleveland Engineering Society has set all of us a good example and pointed the way to effective work. Most of you probably read a few weeks ago in one of the engineering papers an article on "Publicity Work of the Cleveland Engineering Society,"¹ as well as the editorial comment on that article. About a year ago that society awoke to the fact that engineers and engineering work in and about Cleveland were not receiving the attention which they should in the local press, and by the appointment of a committee on publicity steps were taken to remedy the difficulty. The editor of one of the daily papers expressed the opinion that one reason why news of an engineering nature does not get into the daily press is because the ordinary reporter does not have the technical knowledge to properly handle it, and he suggested that the society should be its own reporter. It is not often that engineers are found who have the faculty of writing a newspaper story and describing engineering work in a manner which will hold the interest of the non-technical reader. If, however, engineers had a sufficient breadth of view, the faculty of clearly expressing their ideas on paper, and, above all, the ability to see their own work from the point of view of other people, a task such as this publicity work should not be difficult. The Cleveland Engineering Society was fortunate in having for the chairman of its publicity committee just such a man, and the results obtained during the past year have been most gratifying, and they undoubtedly serve to raise in a substantial degree the estimation in which engineers are held by the Cleveland public. The editorial comment on the article to which I referred states: "There will be those, doubtless, who will say that such publicity work is undignified and even unprofessional. Such a viewpoint betrays dense ignorance of actual conditions at the present day. It is of the greatest importance, both for the welfare of the public and the engineering profession, that the public should have a more intelligent understanding and appreciation

¹ *Engineering News*, Jan. 22, 1914.

of the work of the engineer. Every engineer of long experience can recall many cases where the greatest difficulty he has had to contend with has been to make those for whom he was working — public authorities, boards of directors or private clients — understand and appreciate the importance of the particular task in engineering under consideration, and the need for its study on broad lines. . . .

“Every large business organization nowadays recognizes the great value and importance of publicity, and this not merely from the point of view of the sales department alone. High standing and reputation in the community are just as important a factor to a corporation or a firm as they are to an individual. Exactly the same rule applies to a profession. Any method by which it may have its work, its achievements, its standards and its aims laid before the public which it seeks to serve is a matter deserving serious attention.”

There are many ways in which this Society may actively participate in public affairs to the mutual benefit of the community and our profession; and in this connection we may well take note of the work of that efficient business organization, the Boston Chamber of Commerce. That body, through its committees, is constantly studying live questions of local interest, many of which are more or less of an engineering character. Among them may be mentioned the agitation for the provision of a 40 ft. channel as well as numerous other improvements for Boston Harbor, waterway developments throughout New England, the White Mountain forest reserve, fire prevention, the modification of our city building laws, street improvements and comprehensive city planning. These are but a few of the many lines of investigation which the Boston Chamber of Commerce has recently undertaken, and they are typical of the public questions which should be considered. In much work of this character the Boston Society of Civil Engineers might well coöperate with the Boston Chamber of Commerce, and if this Society will but shake off its lethargy, and undertake to apply itself to the solution of some of the live questions of the day, it will find plenty of work cut out for it, and it will find, also, that it can be of real help to the community.

I am glad to say that the Society has only just rendered a public service whose importance we may not appreciate. In securing the paper on Boston foundations, with its compilation of a vast amount of information regarding soil conditions in all parts of the city, together with the extended discussion which this paper brought forth, the Society has rendered a real service to the community, and especially to architects and builders and others besides engineers who have to do with the building operations in this city. To render this particular service complete, this paper, with its diagrams and the full discussion, should be reprinted and made available to all who wish to use it.

I am well aware that many of the views which I have expressed will not be accepted by all who are present, and of those who differ from me many will be found who complain of the present status of the engineer. To my mind, we must face conditions squarely, and work individually and concertedly to improve them or else hold our peace. It is for us to choose between pessimism and progress.

CONCLUSION.

To sum up briefly, the message which I wish to convey is this: that, as I see it, the engineering field is broadening, opportunities are multiplying on every hand, and the outlook for the future is bright; but the times demand that the engineer be of a higher and much broader type than he has been heretofore. We must be much more than simply engineers in the old and narrow sense; we must be men of affairs, aggressive and alert, with the courage of our convictions and in touch with public questions. Individually and collectively, we must take our share of the world's work and actively participate in the solution of the pressing public questions of the day. If we engineers, as individuals, awake to the opportunities and the responsibilities that lie before us, and fit ourselves thoroughly for the higher duties that await us, we may be sure there will be no flagging in the world's material progress during the twentieth century, and that, in due time, the engineering profession will receive that degree of recognition to which it is justly entitled.

BOSTON SOCIETY OF CIVIL ENGINEERS

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INDEX TO ADVERTISERS.

	PAGE
A. B. SEE ELECTRIC ELEVATORS, 111 Devonshire St., Boston.....	XVIII
ABERTHAW CONSTRUCTION Co., 8 Beacon St., Boston.....	XV
ADAMS, H. S., 108 Ames Building, Boston, Mass.....	IV
AMBURSEN COMPANY, 61 Broadway, New York.....	XVII
ASPINWALL & LINCOLN, 3 Hamilton Pl., Boston.....	IV
ASSOCIATED ARCHITECTS PRINTING & SUPPLY Co., 144 Congress St., Boston.....	XVII
ASSOCIATION OF ENGINEERING SOCIETIES, 3817 Olive St., St. Louis..	XVI
BAY STATE DREDGING Co., LTD., 247 Atlantic Ave., Boston.....	X
BISHOP, J. W., & Co., 683 Atlantic Ave., Boston.....	XI
BLAIR, ISAAC, & Co., INC., 433 Harrison Ave., Boston.....	XI
BOSTON PHOTOCOPY PRINT Co., 7 Water St, Boston.....	XVI
BRADBURY, ROYALL D., 18 Tremont St., Boston.....	III
BRINE, R. S., TRANSPORTATION Co., 43 India St., Boston.....	VIII
BROWN, BURTIS S., 88 Broad St., Boston.....	IV
BUSS, EDWARD A., 85 Water St., Boston.....	IV
DEAN, F. W., INC., 53 State St., Boston.....	IV
DETROIT GRAPHITE Co., 94 Milk St., Boston.....	XVII
EASTERN EXPANDED METAL Co., 201 Devonshire St., Boston.....	XVI
FORT HILL PRESS, 176 High St., Boston.....	XVIII
FULLER, ANDREW D., Co., 3 Hamilton Pl., Boston.....	XII
FULLER, GEORGE W., 170 Broadway, New York.....	IV
GOW, THE CHARLES R., Co., 166 Devonshire St., Boston.....	XIII
GREEN FUEL ECONOMIZER Co., 141 Milk St., Boston.....	XVI
GURLEY, W. & L. E., Troy, N. Y.....	XIX
HALL, JOHN G., & Co., 114 State St., Boston.....	XVII
HERING & GREGORY, 170 Broadway, New York.....	IV
HERN, J. L., ENGINEERING Co., 149 Pearl St., Boston.....	IV
HERSEY MFG. Co., South Boston.....	XX
HOLBROOK, CABOT & ROLLINS, CORPN., 6 Beacon St., Boston.	VII
HOLZER, U., 25 Bromfield St., Boston.....	X
HUGHES, EDWARD F., 8 Oliver St., Boston.....	XVII
JACKSON, D. C. & WM. B., 248 Boylston St., Boston.....	IV
JONSBURG, F. F., Co., 733 Old South Building, Boston.....	XI
KELLOGG, ALFRED S., 53 State St., Boston.....	IV
LEDDER & PROBST, 56 Franklin St., Boston.....	XVI
MCQUESTEN Co., THE GEO., 27 Kilby St., Boston.....	XV
MAIN, CHARLES T., 201 Devonshire St., Boston.....	III
MAKEPEACE, B. L., 12 Bromfield St., Boston.....	XVII
METCALF & EDDY, 14 Beacon St., Boston.....	IV
MILLER, HIRAM ALLEN, 8 Beacon St., Boston.....	IV
MILLER, WILLIAM L., 71 Alford S., Boston.....	VIII

	PAGE
OLD CORNER BOOK STORE, 27 Bromfield St., Boston.....	XVII
PENNSYLVANIA CEMENT CO., 166 Devonshire St., Boston.....	XI
PERRIN, SEAMANS & CO., 57 Oliver St., Boston.....	XVIII
ROCKPORT GRANITE CO., Rockport, Mass.....	VI
ROEBLING CONSTRUCTION CO., 101 Tremont St., Boston.....	XI
SIMPSON BROS. CORPN., 166 Devonshire St., Boston.....	VI
SMITH, B. F., & Co., 60 Federal St., Boston.....	XV
SPAULDING PRINT PAPER CO., 44 Federal St., Boston.....	XIII
STONE & WEBSTER, 147 Milk St., Boston.....	IX
THOMPSON, SANFORD E., 141 Milk St., Boston.....	V
THOMSON METER CO., 100 Bridge St., New York.....	XV
THORPE, LEWIS D., 201 Devonshire St., Boston.....	V
TUCKER, EDWARD A., Co., 683 Atlantic Ave., Boston.....	VI
TYSON, WEARE & MARSHALL Co., Beacon Building, Boston.....	XVI
WALDO BROTHERS, Boston.....	X
WARREN BROTHERS CO., 59 Temple Place, Boston.....	XIV
WARREN FOUNDRY AND MACHINE CO., 111 Broadway, New York...	VIII
WESTON, ROBERT SPURR, 14 Beacon St., Boston.....	V
WHEELER, CHARLES D., 65 Kilby St., Boston.....	XIII
WHITMAN & HOWARD, 220 Devonshire St., Boston.....	V
WOOD, R. D., & Co., Philadelphia.....	VIII
WORCESTER, J. R., & Co., 79 Milk St., Boston.....	V

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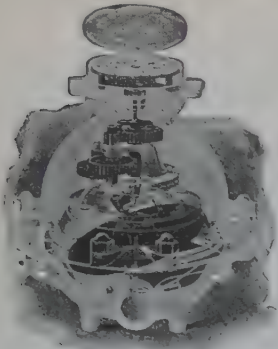
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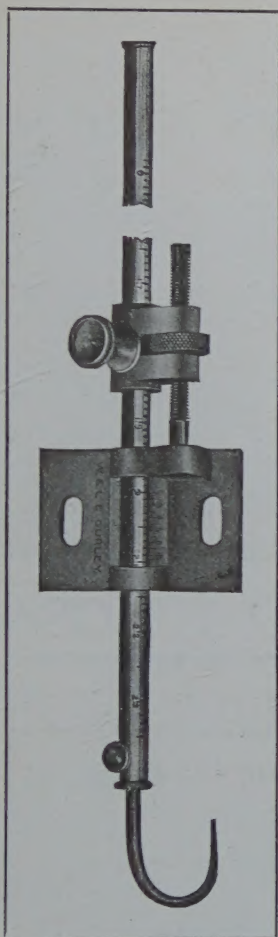
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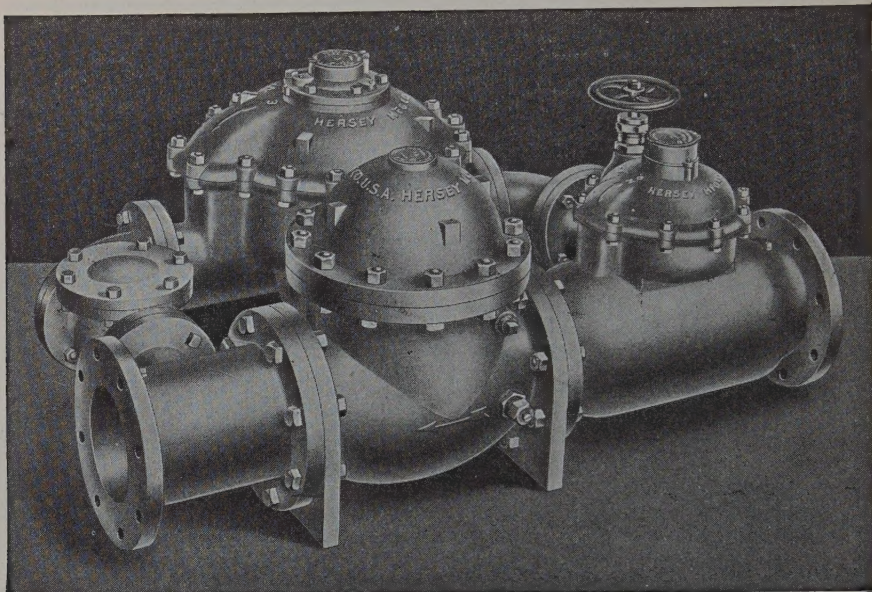
The entire arrangement is such that the readings can be taken by the observer with the greatest possible convenience and at some distance from the surface of the stream or ditch being measured, which is often a decided advantage. This is especially so in the East, where many of the streams are

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